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GOALS IN TECHNICAL EDUCATION

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Goals in Technical Education," submitted by John G. Williams in partial fulfilment of the requirements for the degree of Master of Education.

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ABSTRACT

The immediate purpose of the inquiry was to develop and test an Opinionaire designed to explicate objectives for the Chemical Technology course at an Institute of Technology.

A set of twenty-five possible objectives was identified from analysis of current course syllabuses and from interviews with persons believed to be knowledgeable in this field. These items were ranked by three groups of respondents into a nine-category Q-sort distribution according to each respondent's opinion as to the relative importance of the item as an objective for the Chemical Technology course. Mean ranks for each objective for various groupings of respondents were calculated and tested for significance of difference.

It was found that the different groups of respondents agreed substantially as to the three or four most and least important objectives. As expected it was also found that there were significant differences in group rankings for a number of the other objectives.

The evidence indicated that the Opinionaire provided an explicit and adequate statement of objectives for the Chemical Technology programme and that it was capable of

identifying differences in opinions of referent groups with regard to these objectives.

The conclusion was drawn that the technique of the Opinionaire has valuable possibilities in defining operational goals for Technical Education, and that extension of the technique to other programmes is warranted. It was also suggested that the Opinionaire technique may be found to be a useful tool towards building a comprehensive theory of goals in Technical Education.

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CHAPTER I

INTRODUCTION AND BACKGROUND

The purpose which differentiates Technical Education from other educational institutions is its direct concern with the development of the occupational competence of its students. There is much agreement with this statement. To say it however, is to describe what has become a philosophical value of technical educators rather than to state objectives which can be used to guide planning for future expansion, to prepare curricula, or to serve as criteria for evaluating effectiveness. For such operational uses the value occupational competence has to be translated into more meaningful terms. It also has to be set in some kind of relationship with other values held by society in general or by specific institutions and groups which have a particular interest in Technical Education.

I. GENERAL PURPOSE OF THE STUDY

Later in this chapter it is pointed out that there are many of these institutions and groups, each holding its own mix of values and generating its own resultant force on Technical Education. Often such institutional and group

forces and their effects on Technical Education are not clearly recognized, and there is a need for tools with which to trace the relationships between the forces and especially to analyse their effects as directions to be taken by Technical Education.

The task of this study is to investigate one type of tool or technique which may be found useful for this kind of analysis and which will enable the vague goals of occupational competence to be expressed in terms which are more reliable and meaningful for operational purposes. The general purpose of the study is thus to contribute towards clarifying the purposes or goals of Technical Education.

As far as is known the opinionaire technique used in this study has not previously been applied to the goals of Technical Education. Accordingly this is seen as a pilot investigation in which the technique is used in an attempt to explicate the objectives of one only of the several hundreds of courses offered in technical institutions. It is believed that success in clarifying purpose for one programme would constitute a warrant for extension of the same technique to other programmes and other facets of Technical Education.

II. THE SIGNIFICANCE OF THE STUDY

The study is significant at two distinct levels. In the first place, administrators in Technical Education are constantly faced with the problem of determining and then verbalising the objectives to be sought in programmes of occupational training. In selecting objectives they have little to guide them but their own intuitions and those of a small number of advisory committee members. Considerations of curricula in advisory committee meetings tend to lack focus for discussion and evidence to support subjective opinions. Members tend to bypass definition of objectives and to concentrate on general or specific topics to be included in or excluded from the syllabus. Final selection of topics is presumably made in terms of objectives, but these are rarely made explicit. The aims sought by different advisers may or may not coincide with one another's, or, indeed, with those of the groups they are supposed to represent. Hugh King questioned whether advisory committee members as a class might be too senior and not close enough to the job. "Their advice may be coloured too much by their recollection of what job requirements used to be."[1] Other questions

might be asked about the reliability and validity of a sample of five or six persons presumed to represent some hundreds of legitimate view holders, about the extreme difficulty which advisory committee members often have in dissociating industrial controversy from educational purpose, and about their capacity to project their thinking far enough ahead in times of rapid change in training requirements.

In this study it is accepted that, until Technical Education has access to more extensive research techniques and resources, opinion and the advisory committee system will remain the fundamental guides to course objectives and curricula. It is not accepted that current procedures within that system are sufficiently systematic, efficient and effective. Any technique which will tap a larger reservoir of pertinent opinions and enable them to be served up to advisory committees in explicit pre-digested form will immediately provide a focus for discussion and improve the effectiveness of the committees' proceedings. This alone is a worthwhile gain which a proven opinionaire technique could contribute.

There is another way, even more important, in which this pilot study is significant. The study is motivated

by two deep convictions. The first is that the functions of Technical Education in society and the complex issues these functions involve are of sufficient size and significance to warrant recognition of Technical Education as a distinct field of theoretical study. The other is that the accelerating pace of expansion in this field demands improved planning, which starts with clear perception of purpose. The pace of development, stimulated by tremendous inpourings of finance from central governments, is now so rapid and the ultimate effects of immediate decisions so far-reaching that customary trial- and -error forms of advance cannot be tolerated. More objective and systematic planning and decision making processes are urgently required, with their base in a clearer sense of direction. Administrators need a frame of reference which is comprehensive enough to bring into full view all the forces, and the sources of the forces, which impinge on Technical Education and control the directions it must take.

It is not the business of this study to attempt to develop such a conceptual framework. Only a brief view is taken of these forces and their sources and the Opinionaire is concerned with only a few of them. Nevertheless the study is seen as a significant, if small, step towards a

rationale or framework within which the purposes of Technical Education may be more systematically understood. The Opinionaire is believed to be a tool with which much of the necessary examination may be made. By testing the effectiveness of the Opinionaire technique the pilot study prepares the way for more extensive development and analysis of a comprehensive rationale of goals in Technical Education.

The Complex Environment of Technical Education

The urgency of the need for such a rationale and for the development and application of research tools in this field may be appreciated from a brief review of the environment in which modern Technical Education operates.

The history of Technical Education in Australia, of Further Education in Britain, and of Vocational and Technical Education in North America, is characterized by haphazard, opportunistic, uneven response to uncoordinated and hazy social, political, military, economic and industrial pressures. The fixed pole of vocational competence has provided a strong underlying sense of direction, but development and expansion have been regulated by immediate (sometimes past) needs rather than by a rational understanding of trends or ordering of priorities. Technical Education has had

little control of its own destiny. In the English-speaking world it has suffered, until the last decade, from a sense of inferiority resulting in part from pervasive seventeenth-century British academic values, in part from the lowly image presented by its visible symbols, but in part also because of a tendency shown by some technical educators in the past to accept a narrow and superficial view of the contribution of Technical Education.

One result of this image has been a tendency for Technical Education to withdraw into itself, to operate, in Marie Jahoda's words, as a closed system, with firm boundaries which restricted contact with other forms and levels of education and dimmed recognition of relations with other social institutions.[2]

In the last ten years there has been an obvious change in the external climate for Technical Education in the English-speaking countries. Rapid displacement of hand by head technology combined with national economic growth targets has brought sudden recognition of the dependence of individual and national well-being on human resource development. The most apparent signs of the change of climate have been the spectacular financial interventions into Technical Education of the central governments of

Australia, Britain, Canada and U.S.A. The most significant aspect of the change has been the explicit concern of these governments with the social and political, as well as with the economic and personal, outcomes of education for work.

In spite of the severe temptation for Technical Education to invest all of its new found wealth in the more tangible and easily developed resources such as upgrading of obsolete buildings and equipment, there is growing awareness that quality in Technical Education and its worth to individual and national interests are closely linked to investment in teacher growth, in programme improvement, in research, and most especially in more rational planning.

Rational planning starts with goals and proceeds in large part by analysing broader goals into progressive series of more specific and operational sub-goals. As Ziel says, each level of the sub-goal hierarchy involves specification of action programmes to realize the sub-goals, assignment of each programme to an accountable person or institution, prescription of standards of performance, and a system of evaluation and review.[3] Each stage of this sequence involves a complex of assumptions, values and hard

realities, through which technical educators in the past have erratically navigated by intuitions derived from experience. Of prime concern always have been the two explicit aims of developing marketable skills in students and of meeting industry's labour requirements. In the days of relative simplicity and stability in the work force structure, the experience of the past and the traditions of training institutions such as apprenticeship and evening study provided adequate, if not ideal, guides to action. The only theoretical illuminations needed were the above two relatively clear and uni-variate aims. Formal Technical Education could operate as a closed system with skill development as its primary acknowledged task. The boundaries of this system extruded only slightly into the outside world to admit the industrial advisory committees.

In the complexity of the expanding technological economies of the more advanced nations, the aims of Technical Education have become multi-variate and therefore much less easily understood and attained. Relations with industry, formerly simple, have become much more than merely operational problems of setting up and maintaining amicable relations with advisory committees. They now involve the

conceptual problems of defining and continually re-defining roles in a partnership. The student body is more heterogeneous in terms of background, age and destination, and has upset traditional patterns in finance, physical facilities, teacher supply and preparation, and especially in learning processes and curriculum organization. The type of planning required to cope with these and the many other rapidly changing variables within the Technical Education system depends on a broader range of research-backed concepts, and therefore on a higher level of theory development, than has previously appeared necessary in this field.

Of even greater consequence are factors in the external environment of Technical Education which make it impossible for its administrators to continue to act as if theirs is a closed system. The current surge of investment in Technical Education is a direct consequence of government acceptance of new emphasis on economic theories of human resource development. Adam Smith and Alfred Marshall recognized long ago that "the most valuable of all capital is that invested in human beings"[4] but this concept has recently been extended and popularized, notably by T. W. Schultz[5] and Harold F. Clark[6] in America and by Vaizey[7] in

Britain. Economists such as these have attempted to analyse and measure returns from investment in human capital in terms of personal and national economic gains and have established convincing evidence of the interdependence of education and productivity.

At the same time, growing interest in education as investment has been balanced by sociological review of the role of education by such people as Havinghurst[8] and Becker.[9] They consider for example the functional and symbolic relations of education to social stratification and mobility. With more obvious relevance for technical educators, Venn[10] as well as Brookover and Nosow[11] in America have examined the social functions of vocational education in modern society. On the other side of the Atlantic Cotgrove has traced the social forces which sustained and directed English Technical Education in its first hundred years.[12] In Australia, too, as S. Murray-Smith has demonstrated, the original purposes of Technical Education were more social than industrial.[13]

Other sociological determinants of Technical Education identified by Eli Ginzberg[14], G. E. Arnstein[15] and Ziel[16] include demographic issues, such as age, sex and race structure of the work force; the increasing permeation of

science and technology with consequent accelerating obsolescence of knowledge and skills; changing social values which presage reduction of working hours and increased leisure for many, as well as extension of education for most.

In the political sphere Technical Education is seen as a vital weapon in defence and deterrence, as a vehicle of enlightened self-interest in international aid, as an area of jurisdictional controversy and national cooperation in federations such as U.S.A., Canada, and Australia. It is also seen as a major tool in the urgent talk of uplifting culturally or racially depressed minorities.

Of particular importance to Technical Education is current government concern with active manpower policy, which involves the social, demographic, political and economic issues already mentioned. The preamble to the Canadian Technical and Vocational Training Agreement (1961-1966) explicitly states that manpower development is its major purpose, and the ten programmes under this agreement have very decidedly influenced the direction and pace of Technical Education in that country.[17] Similar purposes underlie corresponding acts in Australia, U.S.A. and

Britain, with similar decisive effect on the Technical Education systems.

The purpose of this section so far has been to indicate briefly the tremendous range of economic, political, social and cultural dimensions which exist in the external environment of Technical Education.

To these external dimensions should be added two more immediate environmental spheres, the industrial and the educational systems. The many mutual cause and effect involvements of Technical Education with each of these spheres have scarcely been identified, let alone analysed. Yet each introduces a whole range of parameters into the planning and practice of Technical Education. One example of an emerging trend which needs clarification is the tendency for many young people and their parents to regard technical courses less as a preparation for specific employment than as an alternative form of general education appropriate to modern technological culture. Another example is the growing concept of partnership or shared responsibility for training between Industry and Technical Education. This was the theme of the Pan Indian Ocean Conference on Technical Education and Training held in Western Australia in 1966. Its clearest expression in the

English-speaking world is Britain's recently formed pattern of Industrial Training Councils.

The discussion in the last six pages illustrates the variety and complexity of the many influences which shape the goals of Technical Education. Only a few of these influences are of direct concern in this pilot study, but some survey of the many is necessary to provide perspective for the few.

III. THE NATURE OF TECHNICAL EDUCATION

Before proceeding to describe the nature of the pilot study in more detail, it is necessary to specify the way in which the term Technical Education is used in this thesis, as it denotes different things in different countries. A brief survey of usages in four countries will clarify its meaning in this inquiry.

In Australian usage Technical Education in the broadest functional meaning comprises all those forms of instruction and learning which occur in technical schools and colleges and in the recently established Institutes of Technology. It therefore includes peripherally much that is normally regarded as general education as well as leisure and creative activities. In a minority of States,

Technical Education also takes in technically biassed or vocational preparatory programmes in high schools. In this thesis however, the term Technical Education is used in a more restrictive sense which represents the hard common core of Australian usage. This is the sense in which H. S. Williams says,

> There is no doubt, however, that occupational preparation, job efficiency and qualifications for promotion are the major purposes of most students undertaking technical education.[18]

Occupational relevance is the distinguishing characteristic of instruction and learning in Technical Education, most of which takes place in institutions devoted primarily to this end. The technical training institutions in all States of Australia list much the same range and type of job-slanted programs, covering professional, technician, trade, commercial and other courses for many forms of industry, commerce, agriculture and home employment. Technical Education caters for students of many levels of educational background and of all ages beyond school leaving. The common link between all students and programmes is the employment intent.

In Canada, a fairly precise description of a somewhat similar range of activities under different nomenclature

is offered in the Technical and Vocational Training Agreement which defines "technical and vocational training" to mean

> any form of instruction, the purpose of which is to prepare a person for gainful employment in any primary or secondary industry or in any service occupation or to increase his skill or proficiency therein, and, without restricting the generality of the foregoing, includes instruction for that purpose in relation to any of the following industries or occupations: agriculture, forestry, fishing, mining, commerce, construction, manufacturing, transportation or communications, or generally any primary or secondary industry or service occupation requiring an understanding of the principles of science or technology and the application thereof, except where such instruction is designed for university credit.[19]

This definition is made more clear and specific by the descriptions of the ten distinct programmes included in the Agreement. With two major reservations, this Canadian definition corresponds closely with what is called Technical Education in Australian terminology. The reservations are, firstly that most Australian States do not include formal Technical Education in high school courses, though a number of "practical subjects" are provided, and secondly that Australian Technical Education does include courses of university first degree level but with a different bias, in fields such as engineering, architecture, applied

sciences, management, etc.

In the case of Great Britain there is sometimes confusion between the terms Further Education and Technical Education. Further Education corresponds roughly with the very widest Australian interpretation of Technical Education, and in Dent's words

> comprises all forms of public education provided by statutory and grant-aided voluntary bodies for persons beyond compulsory school age, except secondary and university education and teacher training.... It can be divided into three branches: vocational education, cultural studies, and social and recreative activities.[20]

The Robbins Report defines Further Education as comprising all other (than university, teacher training and adult education) institutions providing post-school education within the sphere of responsibility of the Minister.[21] The Scottish Education Department defines it as including

> a wide variety of forms of post-school education such as adult education, technical education, continuation classes, youth service, community centres and the work of the many voluntary educational agencies.[22]

It should be noted that British Technical Colleges and Colleges of Advanced Technology offer university level courses and there is some disagreement as to whether such technological education is a part of technical education. Clearly, however, in British terminology Technical Education

is one part of Further Education. Venables began an attempt to set down a meaningful statement of what Technical Education is with an unpromising quotation from T. H. Huxley: "It passes the wit of man so far as I know to give a legal definition of technical education."[23] The best he could offer were the two equally tautological alternatives "the education carried on in technical institutions"[24] and "the work of an institution whose Principal is a member of the Association of Principals of Technical Institutions."[25] Technical Education in Britain may be regarded as that part of Further Education which is primarily oriented towards employment rather than culture or recreation. A British Information Services pamphlet states that

> Technical Education is education and training related to employment in industry and commerce.... It will be interpreted in the broadest sense as being concerned with the production of skilled manpower at many levels, from operatives and technicians to technologists, managers and members of the professions.[26]

With regard to the United States, a different problem of definition arises. Here the term Technical Education has come to be pre-empted for forms of job-oriented education at the level of thirteenth and fourteenth grades. Often it is applied to the kinds of courses given typically by the

American version of the technical institutes, and it is sometimes restricted to post-high school courses of one to three years intended to train engineering and scientific technicians. (See for example Venn[27]). In one authoritative statement, by the President's Panel of Consultants, technical education is

> considered to be a part of the national continuum of vocational education ... a phase of vocational education having certain unique characteristics, usually requiring more rigorous science and mathematics background and more exacting skills.[28]

The same statement uses the term vocational education

> to refer to all formal instruction for both youth and adults, at the high school, post-high school, and out-of-school levels (but excluding instruction leading directly to a baccalaureate or professional degree) which prepares individuals for initial entrance into and advancement within an occupation or group or related occupations.[29]

One of the best clarifications of a somewhat confused terminology is McLure's explanation:

> Vocational education, in the broad sense, is formal instruction which prepares individuals for initial entrance into, and upgrading within a socially approved occupation, or group of related occupations, at the high school and post-high school levels of education.[30]

If, he continues, useful occupations are classified as unskilled, semi-skilled, skilled, technical and professional, then vocational education as broadly defined is preparation

for all jobs except professional and unskilled. But in practice the term vocational education has come to be restricted to "the initial stage of preparation for certain vocations at the high school level of formal education,"[31] while technical education is "associated with formal programmes of instruction in a variety of occupations at the post-high school level."[32] For this thesis the term Technical Education coincides with McLure's "broad sense" of vocational education, with the same two reservations as those already made in discussion of Canadian terminology.

One other matter of terminology needs to be recorded. The programme studied in this thesis was the "Chemical Technology" course at a Canadian Institute. This course prepares students for employment as technicians. The term technology has been used throughout in its Canadian sense, as referring to technicians, and not in its British and Australian sense as referring to technologists, i.e. to persons with degree-level qualifications.

IV. THE SPECIFIC PURPOSES OF THE STUDY

In this inquiry an examination was made of the objectives of the Chemical Technology programme at the

Northern Alberta Institute of Technology.

Assumptions

It was assumed that the Institute, in setting objectives for this course, is dependent on the opinions of a number of groups of people who have an interest in the programme. Several of these referent groups are described later, but for the pilot study opinions of only three of the referent groups were sought, the three being those judged most important as well as most accessible.

It was also assumed that the members of these groups would see objectives of the course as consisting of changes to be made in the students. The types of changes considered relevant are discussed at length in Chapter II.

For reasons outlined at the beginning of Chapter II it was believed that some agreements and some disagreements would exist in the opinions held by the three referent groups as to the objectives of the course and that these differences could be identified if the opinions were collected in a systematic way and expressed in explicit terms capable of objective analysis.

Purposes

The specific purposes of the pilot study were

(a) to devise an instrument by which to collect in a suitable form the opinions of the members of the three referent groups.

(b) to discover the extent of agreements and disagreements between the three groups in their opinions regarding the objectives.

The collecting instrument and the techniques associated with it were then to be judged effective if they were found to provide explicit and acceptable statements of the objectives. Corroborative evidence of effectiveness would be the capacity of the instrument to distinguish those objectives about which there was agreement from those about which there was significant disagreement. As stated in the conclusions in Chapter IV, it is claimed that the evidence indicates that these two criteria were met by the opinionaire.

V. THE INSTRUMENT AND PROCEDURES

To accomplish the purposes stated in the preceding section, an opinionaire was developed and administered to samples of three referent groups described in Chapter II. For convenience of reference the opinionaire was labelled "The Chemtech Opinionaire". A copy is included as Appendix A to this report. The Opinionaire and the procedures used

to develop and apply it are described fully in the next chapter. An outline is given here.

In its final form the Chemtech Opinionaire consisted of a set of twenty-five statements of possible objectives for the Chemical Technology course. These are listed in Table I on page 52. As shown later these objectives were derived from analysis of current syllabuses and a series of interviews with persons believed to be knowledgeable in the field of chemical technology. The statements of objectives were printed on small cards, one objective per card, and distributed to the members of the referent groups to be sorted according to instructions given.

The three referent groups and the reasons for choosing them are discussed in Chapter II. Briefly the respondents consisted of the chemistry teachers and principal at Northern Alberta Institute of Technology, graduates of Chemical Technology at that Institute, and employers of the graduates. Seventy-four acceptable responses were received, including Opinionaires from all but one of the teachers, from twenty-five of the forty-seven who have graduated, and from thirty-eight representatives of industry.

The respondents ranked the twenty-five cards into a Q-sort distribution over categories one to nine according to

their opinions as to the relative importance of the items as objectives for the Chemical Technology programme. A numerical value, the same as its category number, was assigned to each objective. This gave a measure of priority or relative order of importance to each item for each respondent. For any one item for any selected group of respondents a mean rank could then be calculated and comparisons made between groups for opinions regarding individual items.

This procedure was followed for each of the twenty-five items. Differences in means between groups were tested for significance, using the statistical procedures proposed by Bottenberg and Ward and described in Chapter II.[33]

A number of the differences in means were found to be significant. The conclusions derived from this evidence are discussed in Chapters III and IV.

The initial concept for the Chemtech Opinionaire and much of the mechanical and statistical procedures used were adapted from Lawrence W. Downey's report on the T.P.E. Opinionnaire.[34]

VI. LIMITATIONS OF THE STUDY

Certain limitations are implied in the restricted

purpose of the study which is primarily directed at testing an instrument. Other limitations inherent in opinionaire techniques have been pointed out by John H. M. Andrews. The latter are discussed first.

Opinionaire Limitations

Andrews raises two general criticisms applying to opinionaire techniques of inquiry.[35] The first is that respondents are required to sort all items in order of importance, including any which they may consider of no importance at all. To make some allowance for this difficulty, respondents to the Chemtech Opinionaire were invited to state which of the least important categories of objectives, if any, they considered of no importance for the Chemical Technology programme. As reported in Chapter III about forty per cent of the respondents took advantage of this invitation, indicating that the criticism mentioned by Andrews has to be taken into account when results are interpreted.

The second criticism of the opinionaire method is "that the form of the opinionaire and the wording of the items is unlikely to coincide with the way in which any given individual has his own opinions mentally organized."[36] As in Andrew's investigation with the T.P.E., the Chemtech Opinionaire received few negative and many positive comments,

indicating that respondents were satisfied that they were able to express their opinions adequately. In addition respondents were invited to add objectives and indicate a rank of importance for additions if they felt the twenty-five listed did not cover all their expectations. One-third of respondents made some kind of addition. Their suggestions are discussed in Chapter III.

Sample Limitations

The criteria of success for the Chemtech Opinionaire are: (a) the extent to which it is found to express certain persons' perceptions of the goals of the Chemical Technology course explicitly and completely, and (b) its ability to identify agreements and disagreements in those perceptions.

In the course of performing these two tasks, the Opinionaire provides objective information regarding respondents' opinions. Some inferences have been drawn from this information and are discussed in Chapter III.

It has to be stressed that this information is derived from small accidental samples of small populations in one sector of Technical Education and cannot be guaranteed valid or reliable without many replications and extensions. In addition, even if the factual base were firmer, much of the inference would still be conjectural and intuitive, and would

require more expert and penetrating consideration, criticism and discussion than has been attempted.

The intention in uncovering the information and making the inferences is to demonstrate one way of meeting what is believed to be a need in Technical Education. Unless the pilot study is followed by more extensive theoretical and empirical examination of the goals of Technical Education it will have served no purpose other than a personal one.

VII. OUTLINE OF SUCCEEDING CHAPTERS

Chapter II contains a description of the processes by which the Chemtech Opinionaire was developed and administered. The thinking and assumptions underlying the study are considered at length, and the persons whose opinions were sought are discussed. The chapter concludes with a statement of the statistical and mathematical procedures followed.

Chapter III contains a detailed analysis of the data obtained with the Opinionaire, a discussion of comments made by respondents, and a summary of the main indications regarding objectives of the Chemical Technology programme.

The final Chapter begins with an appraisal of the

Chemtech Opinionaire and the associated technique. This is followed by a short discussion of possible implications for a theory of goals in Technical Education and of other possible applications of the opinionaire technique. The chapter concludes with a recommendation for a more comprehensive repetition of the study and for extension of the technique to other areas of Technical Education.

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(24) Venables, *Ibid.*, p. 8.

(25) *Ibid*., p. 9.

(26) British Information Services, *Technical Education in Britain* (London, H.M.S.O., 1962), p. 1.

(27) Venn, *op*. *cit*., pp. 67, 68.

(28) Office of Education, *op*. *cit*., p. 5.

(29) *Ibid*., p. 5.

(30) William P. McLure, *et al*., *Vocational and Technical Education in Illinois* (Urbana: University of Illinois, 1960), p. 28.

(31) *Ibid*., p. 28.

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(33) Robert A. Bottenberg and Joe H. Ward, *Applied Multiple Linear Regression* (Texas: Lackland Air Force Base, 1963).

(34) Lawrence W. Downey, *The Task of Public Education*: *The Perceptions of People* (Chicago: Midwest Administration Center, 1960).

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CHAPTER II

THE DEVELOPMENT AND ADMINISTRATION OF THE CHEMTECH OPINIONAIRE

This chapter begins with an attempt to trace the mental processes and the working procedures by which the Opinionaire was developed from incipient ideas to the final instrument. Following a description of the instrument itself, the chapter concludes with an account of the way in which the instrument was administered to a number of respondents to obtain the data analysed in the next chapter.

I. ASSUMPTIONS UNDERLYING THE OPINIONAIRE

Retrospective and introspective analysis of mental processes is probably best set out in terms of initial and consequential assumptions, preferably linked by logic but also by intuitions. The pragmatic test of the logic and the intuition is the effectiveness for its purpose of the end product, which was in this case the Chemtech Opinionaire. It is this effectiveness which is under test in the pilot study.

The Opinionaire arose out of two distinct sets of assumptions, one concerned with the forces and some of the

sources of the forces which impinge on Technical Education from the environment described in Chapter I, the other set related to the outcomes which might be expected from a Chemical Technology programme.

"Goals" in Technical Education

In any one of its programmes the Technical Education system is attempting to respond to a mix of forces originating in values held by a very large number of institutions and groups. Some of these forces arise within the system itself, the dominant one being the strong attachment to the value occupational competence. Other forces are directed at Technical Education from its immediate environment, which consists of industry on the one side (or output end), and the general education system on the other side (or input end). Further forces reach Technical Education from the more remote environment of cultural, social, economic and political institutions and trends, some directly, others mediated through the industrial and general educational spheres.

The "goals" of Technical Education in general and of particular programmes are a complex resultant of this amorphous mixture of forces. H. A. Simon questions whether it is justifiable to single out any one such force and call

it THE goal.[1] He sees the goals of an action as sets of constraints or conditions or requirements which the action has to meet. In addition, each participant in the action has his own perception of the purpose as the net gain he hopes to make by participating. Furthermore, a "goal" is rarely terminal. Normally the goal of any one action is a sub-goal for a subsequent or more ultimate act.

This thesis is not designed to examine the ultimate sources of all the forces which influence Technical Education in general or the specific technology course in particular, though inferences derived from the study are guided by the consciousness of such forces. The study is concerned rather with the results of a few forces, in the form of opinions of particular groups regarding desirable outcomes of the Chemical Technology course. These opinions are the outward expressions of assumptions and values peculiar to each respondent and derived from his membership in his unique overlap of social, cultural, industrial, etc., groups. The outcomes desired by the respondent represent sub-goals which contribute to more ultimate goals sought by him or his groups.

It is not difficult to list several groups of people who have a close interest in the Chemical Technology programme

in the sense that they expect it to contribute towards goals desired by them. Such groups include industry, both management and labour, the "profession" or Institute of Chemists, the teachers of the programme, the present and past students, their parents, and others. For the pilot study the most readily accessible of these groups were the teachers, the current students, the graduates, and the employers of the graduates. It was thought that these groups were also the ones whose interest was greatest and whose "goals", expressed as opinions, were most relevant and therefore most suitable for testing the instrument. It was preferred not to disturb the present students so only the other three groups were used in the study.

"Objectives" of the Chemical Technology Course

The other major set of assumptions underlying the Opinionaire concerned the expected outcomes or "objectives" of the Chemical Technology programme. The basic assumption appeared as the first sentence of this report, on the first page in Chapter I: "The purpose which differentiates Technical Education from other educational institutions is its direct concern with the development of the occupational competence of its students." In this thesis occupational competence for chemical technicians was taken to be the ultimate outcome of

the Chemical Technology course.

Occupational competence was regarded as a composite of four components labelled respectively knowledge, attitudes, skills, and experience, which then came to be accepted as the "objectives" of the Chemical Technology programme. The first three of these components are so much taken for granted in everyday use in Technical Education as elements of competence that it is difficult to find written substantiation. However, this breakdown of competence is supported by an analysis made by Graff and Street, who also quoted other supporting authors.[2] In general, knowledge, attitudes and skill appear in one form or other in most of these analyses of competence. Charles R. Richards, quoted by Graff and Street, added to these three a dimension dealing with general knowledge of the occupation or field, including reference to "materials, processes, safety and other items which contribute to make an intelligent workman."[3] Graff and Street themselves added experiences and understandings to the other three elements and stressed the interactive quality which integrates all five components into a single constellation known as competence.[4]

For this study, then, occupational competence is

regarded as a compound of knowledge, attitudes, and skills, together with a fourth element related to Richard's general knowledge of the field or Graff's experiences and understandings. Technical Education is predicated on an unquestioned assumption that knowledge and skill can be taught and learned, and on a hope that attitudes can be developed or at least modified. Traditional practice, especially but not only in apprenticeship training, seems to imply belief in the fourth element of competence. This is the kind of "know-how" which comes with experience, not just on a specific job but rather within the particular type of occupational environment. This job sense includes a blend of knowledge, attitude and skill, but extends beyond those elements which are tangible, analysable and teachable. It is a habitual selective awareness of stimuli, an insight into what is or is not relevant or important, a unique way of relating to fellow workers, tools, materials, processes and clients. This aspect of occupational competence is not often identified explicitly, though it seems to be clearly assumed by the many trades and professions which prescribe a period of internship or apprenticeship. In the remaining pages of this thesis this fourth part of occupational competence, a derivation of experience, is

referred to simply, for convenience, as experience.

II. DEVELOPMENT OF THE LIST OF POSSIBLE OBJECTIVES

The preceding section indicated how the four components of competence came to be thought of as four categories of objectives for the Chemical Technology course. As the twenty-five objectives which eventually formed the substance of the Opinionnaire were stated in terms of one or other of these four categories it is necessary to consider each category in more detail and to indicate how the items in each category came to be adopted.

Acquisition of Knowledge

Use of knowledge as a categorical type pre-supposes an operational definition of knowledge. Webster's Dictionary offers "the fact or condition of knowing", expanded to "the fact or condition of possessing within mental grasp through instruction, study, research or experience one or more truths, facts, principles or other objects of perception." Bloom is more analytical but says much the same: knowledge is the least complex activity in the cognitive domain, is mainly characterized by recall or remembering skills, and may be analysed into knowledge of specifics, of ways and means of dealing with specifics, and of universals and abstractions in

a field.[5] In this study there is a well defined context implied in the frame of reference of scientific, specifically chemical, concepts and of an educational setting. In this context it seems reasonable to expect that respondents have a high degree of common understanding that knowledge connotes primarily the condition of possessing certain specifics within mental grasp, but that there is also an implication of other cognitive abilities and skills (identified by Bloom as comprehension, application, analysis, synthesis and evaluation), as they relate to grasping and using concepts, especially chemistry concepts.

The knowledge specifics relevant to the Chemical Technology course, that is the items which were included in the Opinionaire under the knowledge category of possible objectives, were identified by a series of discussions and visits (described later to avoid discontinuity in the present argument). These specifics were found to refer to the following:

(a) knowledge of a range of principles of chemistry,

(b) knowledge of laboratory practices related to (a),

(c) knowledge of statistical method,

(d) knowledge of the principles of physics and electronics which underlie certain rather

sophisticated instruments used in chemistry,

(e) knowledge of employment opportunities and conditions in fields related to chemistry,

(f) knowledge of the way industry is organized and of the nature of processes used in industry,

(g) an elementary knowledge of principles of supervision and work study,

(h) some knowledge of the routines used in the day-to-day administrative operations of laboratories,

(i) a knowledge of first aid measures related to common minor mishaps in laboratories,

(j) knowledge of the types of techniques commonly used to prepare samples for analysis.

Most of the above were identified, at least in elementary form, at a fairly early stage in the construction of the Opinionaire, but a few, for example, (e), (g), and (j), were only brought to attention as possible objectives in the later interviews and trials. The criteria for inclusion in the Opinionaire were simple but, it is believed, logical. For most items there was clear agreement by all or several of the sources consulted, and no doubts arose as to

relevance. Where there was doubt, a suggestion made by one consultant was discussed at length with him and subsequently with two or more other consultants. If the items was seen by any two consultants as a possible objective, it was included. If only one consultant considered it relevant, it was omitted. In fact only one suggestion was rejected, and this one was considered to be implicit in another, included, item.

After initial identification of the knowledge objectives or possible objectives, two problems had to be settled. The wording of all items had to be made clear and unambiguous, and for some items questions of breadth and depth of knowledge arose. The matter of improving wording is dealt with later when procedures are discussed. Here the question of depth and breadth is considered.

Dimensions of Breadth and Depth. For most of the possible objectives listed above as (a) to (j), the consultants and other sources made it clear that the questions at issue were simply whether or not the item was to be considered an objective of the course and, if it was, how important was it. In these cases, which clearly included items (e) to (j), there was no need for indicators of breadth or depth of knowledge required. For items (c) and (d) it

took a little more discussion with consultants in industry and Technical Education to reach the conclusion that these two items also did not need to have indices of breadth and depth. The same discussions made it clear that such indices were required for items (a) and (b) which covered theory and application of chemistry.

The first breakdown which emerged from consideration of these two items was the distinction between the industrial applications and the theoretical understandings of chemistry, the latter including associated laboratory bench work. It was also made clear in consultations that in each of these two sub-divisions provision would have to be made for expression of different views as to required depth and breadth. With regard to the industrial applications this raised no serious problem as it appeared that the simple distinction between knowledge to an introductory level and knowledge to an advanced level would be adequate.

With respect to knowledge of theoretical aspects of chemistry, analysis of technician-level programmes at Northern Alberta Institute of Technology, British Columbia Institute, Western Australian Institute, Sydney Technical College and in London City and Guilds syllabuses showed a considerable measure of agreement regarding the topics of chemistry

covered at corresponding stages. Though this consensus cannot be taken too far it did support the view that there is a traditional pattern of progression in chemistry courses, with a high degree of uniformity in topic and treatment at the equivalent of high school completion and in each subsequent year of study in a technical type of institution. (This situation may change as the current new approach to high school sciences takes different directions in different countries.) In Technical Education decisions regarding subject credits for students from other institutes are normally made on the assumption of comparable levels of sophistication in comparable years of high school study of the subject.

In this study therefore breadth and depth of knowledge of chemistry were estimated, to a sufficient degree of discrimination, in terms of years of study, completion of high school chemistry being taken as base. All respondents were to be persons who would have taken post-high school courses in chemistry, or who would have been associated closely with graduates of such courses. It was therefore believed that they would have adequate common understandings of the range of chemistry concepts and the level of treatment implied in the following three statements of possible

objectives:

(a) knowledge beyond high school of the common chemical theoretical principles and laboratory practices,

(b) knowledge of the main divisions of chemistry theory to a level one year beyond high school,

(c) knowledge of the main divisions of chemistry to a level two years beyond high school.

These three statements, modified to improve clarity, subsequently became items 1 to 3 in the Opinionaire.

The years-of-study basis for measuring breadth and depth of theoretical knowledge has an important advantage in that it is directly transferable to programmes other than Chemical Technology at the technician level, as well as across the barriers between trade, technician and professional courses. This is important for cross-level comparisons in developing a conceptual framework for dealing with goals in Technical Education.

Altogether, twelve items involving knowledge and one (referring to preparation of samples) classified as knowledge and skill were included in the Opinionaire. These, in the form ultimately adopted after revisions, became items 1 to 13. They are included in Table I on

page 52.

Development of Skills

The main types of skills to be considered as possible objectives of the Chemical Technology course were identified quite early in discussions and references to sources as (a) skills in dealing with laboratory equipment and processes and (b) communication skills. A later addition was the reference already mentioned to skill in sample preparation.

Communication skills were split, as a result of consultation, into skill in writing technical reports and skill in reading and understanding technical instructions.

The laboratory skills needed closer examination. Technicians were observed at work in a number of research and industrial laboratories, and they and their supervisors were consulted as to what they did and what they thought they should be trained to do. It gradually became clear that a variety of distinct skills was involved, but that these fell naturally or logically into groupings which would give adequate measures of the extent (breadth) of skills required. This led to the three following statements of possible laboratory skill objectives:

(a) skill in using laboratory equipment, instruments, and processes,

(b) skill in calibrating, maintaining and repairing equipment,

(c) skill in adapting equipment and processes.

Only the first of these was found to need further breakdown to provide distinction in depth or level of sophistication, and two Opinionaire items, numbers 14 and 15, met this need.

The skill items, then, as subsequently refined, became numbers 14 to 19 in the Opinionaire, as shown in the list on page 52.

Attitudes

Inclusion of a category dealing with attitudes raised questions of definition, measurement and overlap. For a full discussion of the meaning and classification of attitudes the reader is referred to Bloom's treatment of the affective domain.[6] For this thesis the definition in Webster's Dictionary was considered adequate: "an attitude is a persistent disposition or organismic readiness to act positively or negatively towards a person, group, situation or value."

As a result of the consultations and reference to sources described in Section III of this chapter, the range of attitudes which appeared to be worth consideration

was limited to the following:

(a) attitude to safety,

(b) attitude to the employer or firm,

(c) attitude to work,

(d) attitude to accuracy and precision,

(e) attitude to self-improvement.

In early discussions and trials it was obvious that different frames of reference of respondents would lead to problems of interpretation. Short explanatory phrases or illustrations were added to the statements of attitude items, and subsequent trials indicated that respondents then felt more confident in dealing with these items. This was of course no guarantee that all were interpreting the items in the same way. It did, however, provide for acceptable expressions of opinion as to whether and which attitudes were seen as objectives of the Chemical Technology course.

It was not thought necessary to consider strength or depth of commitment to the attitudes. The purpose was to gauge respondent's views as to whether the Technical Institute has a responsibility to attempt to cultivate these or other attitudes at all.

Items 20 to 24 in Table I covered the attitude

category of possible objectives.

Experience

This category has already been discussed to some extent in introducing it earlier. The short title does not adequately connote that intangible awareness or insight which is the subject of this category, and which was included on empirical rather than any theoretical grounds. The view is widespread that some component of job competence is only or best acquired by on-job experience. This view is indicated by the persistent traditions of apprenticeship and internship in many forms of occupational training, and by the more recent experimentation with cooperative, day-release, block release, programmes, which attempt to combine concurrent on-job experience with the more clearly "educational" experiences.

At the professional and trade levels explicit provisions for experience are commonly specified in training programmes, but no clear pattern has yet emerged at the technician level. Views expressed range from that of an Alberta employer who said in a recent interview that experience was not at all necessary to that of a Western Australian group who preferred technicians to learn on the job with evening classes as supplement.

The first versions of the Opinionaire provided for opinions to be expressed as to amount and type of experience considered desirable. It soon became evident that this was not a highly rated objective and that any attempt to discriminate either levels or breadth of experience preferred was unrealistic. Accordingly only one item, number 25, was found necessary under this category.

"Goals" Related to "Objectives"

After the four types of components of the occupational competence of technicians had been analysed into twenty-five specific "objectives" for the Chemical Technology course, it was necessary to relate these back to the assumptions set out in the beginning of this chapter under the heading "'Goals' in Technical Education."

From the outside point of view, that of the employers, the technicians and other beneficiary groups, including the teachers as seekers of job satisfactions and other personal rewards, the "goals" of the programme were seen as the personal and group values to which they expected the outcomes of the programme to contribute. For employers, for example, the main "goal" is competent technicians in their laboratories. For the technicians, the "goal" is a set of skills they can use to gain employment and possibly advancement.

From the inside point of view, that of the principal and staff in their roles as Technical Educators, the outcomes which the course was designed to produce are contained in the twenty-five specific "objectives" listed in Table I. For this study these "objectives" were seen as sub-goals which the referent groups might use to achieve their various "goals". It was thought likely that some of the course "objectives" would be prized equally by all the referent groups and used by them to contribute to their particular and different "goals". However, because the goals are different, it was also believed that some "objectives" would not be regarded by some groups as very useful for their purposes. Hence it was expected that not all "objectives" would be prized equally by all referent groups.

The purpose of this study was to help principals and technical teachers, through the Opinionaire, to see more clearly what particular mix of "objectives" best contributes to the "goals" of appropriate reference groups. For Chemical Technology the objectives from which the mix was to be selected were those listed in Table I on page 52.

III. THE DEVELOPMENTAL PROCEDURES

Sections I and II of this chapter set out the

assumptions underlying the development of the Chemtech Opinionaire and traced the logical processes which led to the list of twenty-five items appearing in Table I. This section outlines the working procedures by which the assumptions and logic were translated into this final list. Much of this procedural activity is fairly obviously implied or has already been indicated in the earlier sections and is merely recapitulated here.

Sources Consulted for Possible Objectives

A variety of written, verbal and other references were used as sources from which to gather specific suggestions for possible technology course objectives which would lie within the four category framework already discussed. These sources included the following:

(a) examination of the published content of Chemical Technology courses at the following institutions:

Northern Alberta Institute of Technology
Southern Alberta Institute of Technology
British Columbia Institute of Technology
Western Australian Institute of Technology*
Sydney Technical College*
City and Guilds of London Institute*
(* similar courses under other names)

TABLE I

OPINIONAIRE: LIST OF OBJECTIVES

Objective		Number	Brief Title*
KNOWLEDGE	BEYOND HIGH SCHOOL OF THEORETICAL PRINCIPLES AND LABORATORY PRACTICES COMMON TO ALL BRANCHES OF CHEMISTRY	1	K CH HS
KNOWLEDGE	TO A LEVEL ONE YEAR BEYOND HIGH SCHOOL OF THE MAIN DIVISIONS OF CHEMISTRY eg. quantitative, qualitative, analytical, organic, inorganic, physical, stoichiometry, etc.	2	K CH HS+1
KNOWLEDGE	TO A LEVEL TWO YEARS BEYOND HIGH SCHOOL OF ONE OR MORE OF THE MAIN DIVISIONS OF CHEMISTRY eg. quantitative, qualitative, analytical, organic, inorganic, physical, stoichiometry, etc.	3	K CH HS+2
KNOWLEDGE	AT AN INTRODUCTORY LEVEL OF ONE OR MORE OF THE MAIN FIELDS OF INDUSTRIAL APPLICATION OF CHEMISTRY eg. oil, plastics, food, etc. chemistry	4	K IN CH INT
KNOWLEDGE	AT AN ADVANCED LEVEL OF ONE OR MORE OF THE MAIN FIELDS OF INDUSTRIAL APPLICATION OF CHEMISTRY eg. oil, plastics, food, etc. chemistry	5	K IN CH ADV
KNOWLEDGE	BEYOND HIGH SCHOOL LEVEL OF STATISTICAL METHOD	6	K STAT
KNOWLEDGE	OF THE SPECIFIC PRINCIPLES OF ELECTRONICS AND PHYSICS INVOLVED IN CHEMICAL INSTRUMENTATION	7	K ELEC PHYS

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*The brief title is used as well as the number in most of the tables of data as an aid to analysis.

TABLE I (CONTINUED)

Objective		Number	Brief Title
KNOWLEDGE	OF OPPORTUNITIES AND CONDITIONS OF EMPLOYMENT IN THE FIELD OF CHEMISTRY	8	K EMPLOYT
KNOWLEDGE	OF INDUSTRIAL ORGANIZATION AND TECHNOLOGICAL PROCESS	9	K IN ORGPRO
KNOWLEDGE	AT AN INTRODUCTORY LEVEL OF WORK STUDY AND PRINCIPLES OF SUPERVISION	10	K WK STUD
KNOWLEDGE	OF LABORATORY MANAGEMENT PROCEDURES eg. stores control, routing and recording of samples, etc.	11	K LAB MAN
KNOWLEDGE	OF LABORATORY FIRST AID eg. for acid splashes, burns, resuscitation, etc.	12	K FIR AID
KNOWLEDGE	AND SKILL IN TECHNIQUES OF SAMPLE PREPARATION	13	K/SK SAMP
SKILL	IN USING THE COMMON LABORATORY EQUIPMENT, INSTRUMENTS, AND PROCESSES eg. pH meter, microscope, centrifuge, titration, filtration, etc.	14	SK COM LAB
SKILL	IN USING THE MORE SOPHISTICATED OR SPECIALIZED LABORATORY INSTRUMENTS eg. gas chromatograph, mass spectrometer, U.V. and I.R. spectrophotometer, etc.	15	SK SOPH LAB
SKILL	IN CALIBRATION, MAINTENANCE, AND MINOR REPAIR OF LABORATORY EQUIPMENT AND INSTRUMENTS	16	SK CAL MAIN

TABLE I (CONTINUED)

Objective	Number	Brief Title
SKILL IN ADAPTING LABORATORY EQUIPMENT OR PROCESSES FOR SPECIAL RESEARCH OR INDUSTRIAL NEEDS	17	SK ADAP
SKILL IN WRITING TECHNICAL REPORTS	18	SK WRIT
SKILL IN INTERPRETING TECHNICAL INSTRUCTIONS	19	SK INTERP
POSITIVE ATTITUDE TO SAFETY eg. care with hazardous materials, use of protective devices, etc.	20	ATT SAFE
POSITIVE ATTITUDE TO THE EMPLOYING FIRM eg. feeling of loyalty to the firm, responsibility to the work team.	21	ATT EMPLOYR
POSITIVE ATTITUDE TO WORK i.e. willingness to do a good day's work on the job	22	ATT WK
POSITIVE ATTITUDE TO ACCURACY AND PRECISION eg. care in measuring and recording	23	ATT ACC
POSITIVE ATTITUDE TO SELF-IMPROVEMENT eg. by continuing education in evening classes	24	ATT IMPROV
EXPERIENCE IN INDUSTRY eg. planned periods of employment during the course or in vacation.	25	EXPER

(b) readings about technician level education

(c) personal discussions with teachers, technicians, and employers of chemical technicians

(d) experience in helping to construct similar courses

(e) observations made on visits to several different types of laboratories.

Trials of the Opinionaire

Individual and group trials of the instrument were made continuously during the course of construction of the Opinionaire. In the earlier stages the sorting process involved and the wording of items were tried out and discussed with people who had some knowledge of the programme, such as the principal and heads of chemical technology departments in Institutes, as well as senior persons in the chemical industries. Later it was not possible to use those involved in any way with the course at Northern Alberta Institute of Technology (N.A.I.T) as this would have spoiled the restricted sample of respondents available. In the final stages the Opinionaire items and instructions were checked for wording and mechanical operation by having the Opinionaire completed by some twenty graduate students in administration and vocational

education, and as a final trial by staff of the British Columbia Institute of Technology.

As a result of these trials and consultations the Opinionaire items evolved into their final form through three fairly distinct stages. In the first stage the different kinds of possible objectives under each of the four categories were identified. In the second stage the wording was improved and indicators of breadth and depth were introduced. At this stage the objectives were roughly in the form shown as capital letters in the list in Table I. In the final stage minor adjustments were made to the main part of the statements of objectives. Also at this stage explanatory phrases, in small letters, were added and a few words were underlined. This helped to remove or reduce ambiguities and to sharpen distinctions.

At each trial progressive changes were made in the instructions to respondents. Only minor changes were found necessary after a second trial with a group of graduate students and no changes in instructions were made after the trial with the British Columbia staff.

IV. ADMINISTRATION OF THE OPINIONAIRE

The set of objectives which were prepared by the

procedures described above appear in list form in Table I and in card form in the copy of the Opinionaire in Appendix A. The complete instructions to respondents also appear in the copy.

This section contains a description of the instrument and the way in which it was used to collect the opinions which formed the data analysed in Chapter III. The respondents whose opinions were sought are also described in this section and the statistical procedures used are outlined.

Description of the Opinionaire

As already indicated the Chemtech Opinionaire consisted of a set of twenty-five statements of possible objectives for the Chemical Technology course at the Northern Alberta Institute of Technology.

The twenty-five items were to be ranked by each respondent into a Q-sort distribution over nine categories, according to the respondent's opinion as to the relative importance of the items as objectives for the course.

The Q distribution to be used was as follows: one item, perceived by the respondent as the most important objective, was to be placed in the first slot provided in the instrument; two items, perceived as the next most

important, were to be placed in the second slot or category; three items, the next most important, in category 3; four items, next in importance, in category 4; five in category 5; four items were placed in category 6; three in category 7; two in category 8; and one item, perceived as the least important, was to be placed in category 9.

A numerical value, the same as its category number, was later assigned to each objective for each response. This gave a measure of the rank or order of priority for each item for each respondent. For any one item, for any selected group of respondents, a mean rank could then be calculated, and comparisons could be made between individuals and groups. Kendall, quoted by Downey, justifies the mathematical assumptions involved in thus manipulating ordinal as cardinal numbers.[7]

Downey also discusses the reasons for forcing respondents to assign priorities to the objectives.[8] In the present context these reasons are:

(a) to force respondents to check a first tendency to accept or reject the proposed objectives too readily, without adequate consideration of what is implied in each. Before priorities can be assigned, comparisons have to

be made between the statements of objectives as well as between the objectives themselves. Respondents have to give some consideration to a frame of reference within which to make judgements. Part of a frame of reference was suggested in the instructions to respondents, which emphasized, and repeated, that the items were to be ranked in order of importance as objectives for the formal programme of Chemical Technology training, rather than as outcomes of other formative influences.

(b) to provide quantitative measures which could be used to identify agreements and disagreements in opinions.

The Respondents and the Response

About one hundred and fifteen Opinionaires were distributed, half in personal calls and half by mail. Ninety-eight were returned, ten of these not completed, seven not usable, and eighty-one completely satisfactory. These returns included six obtained after follow-up letters were sent.

Respondents represented three referent groups. The first group consisted of the teachers of the Chemical Technology course at Northern Alberta Institute of Technology, together with the Principal. Responses were also obtained

from the Principal and Chemical Technology teachers at Southern Alberta Institute of Technology to enable a check to be made on the extent to which the teachers constituted a homogeneous group irrespective of their Institute. The S.A.I.T. returns were not included in the main stream of the statistical analysis. Completed opinionaires were returned by the Principal, Head of Chemical Technology Department, Senior Instructor and eight instructors at N.A.I.T. Returns were received from the Principal, Head of Department, Senior Instructor and four instructors at S.A.I.T.

The second group comprised the ex-students who graduated in Chemical Technology at N.A.I.T. in 1965 and 1966. A list of all these graduates and information on their first employment destination were very kindly provided by the Canadian Manpower Officer at N.A.I.T. There were forty-seven graduates altogether, twenty-five in 1965 and twenty-two in 1966. Completed opinionaires were ultimately received from twenty-five of these. Of the other twenty-two, several were not traced, some had moved to unknown addresses in other provinces, one employer of five graduates preferred not to participate, and two or three of the graduates did not return the Opinionaires they received.

Two employers cooperatively had the Opinionaire completed by graduates of S.A.I.T. who had taken positions vacated by N.A.I.T. graduates. These gave useful background information but were not included in the statistical treatment.

The third group consisted of representatives of the firms in which the graduates of N.A.I.T. were employed. Where appropriate an attempt was made to have two representatives for each firm, one the immediate supervisor of the laboratory, the other a person in a managerial or personnel position. The graduates were found to be employed by the following:

University of Alberta, several departments, mainly in the Faculty of Chemistry

Research Council of Alberta

Canadian Agricultural Research and Defence Research

Atomic Energy Commission

Provincial Departments such as Oil and Gas Conservation, Air Pollution

Mining companies in Alberta and other provinces

Food Packing

Oil and gas Production, Refining and Distribution

Chemical Manufacturing, mainly from oil and gas raw materials

Fertilizer Manufacturing

For statistical treatment these organizations were classified as predominantly research-oriented or predominantly production-oriented. In "research" establishments, chemical technicians were found to have a wide variety of tasks and functions. In "production" firms, the technicians were mostly engaged on quality control operations.

Most firms cooperated very willingly and several expressed keen interest in the inquiry. Usable Opinionaires were returned as follows:

From "Research" Establishments:	20
including managerial/personnel officers:	8
and laboratory supervisors:	12
From "Production" Establishments:	18
including managerial/personnel officers:	7
and laboratory supervisors:	11

Most of the immediate laboratory supervisors were professional chemists, with at least a first university degree. A number of the managerial officers also were fully qualified chemists engaged on administrative tasks. Summary of completed Opinionaires:

Staff N.A.I.T.	11
Staff S.A.I.T.	7
Industry "Research"	20
Industry "Production"	18
N.A.I.T. Graduates	25
Total	81

Statistical Treatment

The essential lines of statistical analysis were as follows:

(a) Calculation of mean ranks for each objective by groups and sub-groups.

(b) Testing of significance of difference of mean ranks for each objective between pairs of groups and sub-groups. As this is a pilot study, the .05 level of significance was accepted.

(c) Ranking of objectives from 1 to 25 in order of priority within each group or sub-group or respondents, the order being determined by size of mean rank, smallest mean rank indicating highest priority.

(d) Comparison of the different orders of priority of objectives corresponding to different groups or sub-groups of respondents.

(e) Application of t tests of significance to correlation coefficients between the rankings of objectives.

The above analyses are shown in Tables II to X in the next chapter.

The following example is given to clarify any ambiguity there may be as to the calculation of mean ranks in (a) above.

For Objective 8 (knowledge re employment), N.A.I.T. staff assigned ranks (category numbers) ranging from 5 to 8, and the sum of these assigned ranks for the eleven staff members is 70. These raw responses are tabulated in Table X, Appendix B. The mean rank for Objective 8 for N.A.I.T. staff was therefore 6.36, as shown in Table III, column 3. (page 74).

For the same objective, the graduates assigned ranks ranging from 3 to 9. The sum of the assigned ranks for the twenty-five graduates was 176, that is, a mean of 7.04, as shown in Table III, column 11.

The probability that the staff's mean for this objective would differ by chance from the technicians' mean by 6.36 to 7.04 was found by calculation to be twenty-five chances in one hundred. The difference is therefore not statistically significant.

Method of Calculation. Means and significance of differences of means were calculated by the method of

applied multiple linear regression proposed for one way analysis of variance by Bottenberg and Ward[9] and presented by Hunka in "Multiple Linear Regression: Student Notes".[10]

Calculations were processed on the IBM 7040 computer at the University of Alberta, using the Reg 200 programme for linear regression prepared by the Educational Research Services at the University. An IBM card was punched for each respondent, showing in columns 21 to 45 the ranks he assigned to the twenty-five items, and in columns 51 and 52 identifying codes for respondent's group and sub-group.

An example of the calculation programme is shown as Appendix C to this report.

REFERENCES TO CHAPTER II

(1) Herbert A. Simon, "On the Concept of Organizational Goal," *Administrative Science Quarterly*, 9:1, 1964-65, pp. 1-22.

(2) Orin B. Graff and Calvin M. Street, *Improving Competence in Educational Administration* (New York: Harper, 1956), pp. 30-56.

(3) *Ibid*., p. 35.

(4) *Ibid*., p. 30.

(5) Benjamin S. Bloom, editor, *Taxonomy of Educational Objectives Handbook I* (New York: David McKay Company, 1964), p. 46.

(6) *Ibid*., p. 62.

(7) Lawrence W. Downey, *The Task of Public Education: The Perceptions of People* (Chicago: Midwest Administration Center, 1960), p. 29.

(8) *Ibid*., p. 27.

(9) Robert A. Bottenberg and Joe H. Ward, *Applied Multiple Linear Regression* (Texas: Lackland Air Base, 1963).

(10) Stephen S. Hunka, "Multiple Linear Regression: Student Notes," (Edmonton, University of Alberta, 1966). (Mimeographed.)

CHAPTER III

ANALYSIS OF DATA

The responses to the Chemtech Opinionaire are summarized in this chapter in a series of tables of mean ranks. The analysis of data takes the form of a discussion of each table of means. This is followed by a summary of the opinions about each individual objective in turn, and the chapter concludes by bringing together the main indications found from the data. The raw responses are tabulated in full as Table X in Appendix B.

I. THE TABLES OF PRIORITIES

Tables II to VIII show the mean ranks of objectives in the orders of priority expressed by various combinations of respondents. Differences in mean ranks which were statistically significant are indicated. Table IX shows rank correlations.

Order of Priority of Objectives, All Respondents. From the composite rankings of objectives shown in Table II it seems clear that a high level of specialized knowledge of chemistry, skill with the common laboratory equipment and processes, and concern with accuracy and precision are almost unanimously rated the most important tasks of the

Chemical Technology programme. There is perhaps just as much unanimity in writing off as least important objectives 25, 11, 9, 8, and 10, though a couple of these were given more importance by one or other sub-group.

The standard deviations give some guide to the considerable unanimity with which a few of the middle items were consistently placed in similar positions by most sub-groups. Note the small standard deviation for skill in interpreting instructions (Item 19), skill in calibration, maintenance and repair (Item 16), attitude to safety (Item 20), and knowledge of First Aid (Item 12) all of which held their middle positions because most respondents agreed that that was where they belonged.

On the other hand, attitude Items (22, 24, 21) specialized knowledge of chemistry to a moderate level (Item 2), knowledge of electronics and physics (Item 7), and knowledge of industrial applications of chemistry (Items 4 and 5), with larger standard deviations, held middle positions as a statistical compromise between the divergent views already noted. A general knowledge of chemistry (Item 1) and sophistication in laboratory skill (Item 15) finished with high positions because strong support from two or three sub-groups, for example the

TABLE II

ORDER OF PRIORITY OF OBJECTIVES, ALL RESPONDENTS*

N = 74

Objective	Order of Priority of Object	Mean Rank	Standard Deviation
3. K CH HS+2	1	2.76	1.93
14. SK COM LAB	2	2.97	1.31
23. ATT ACC	3	3.01	1.27
1. K CH HS	4	3.69	1.97
15. SK SOPH LAB	5	3.77	1.54
19. SK INTERP	6	4.04	1.38
16. SK CAL MAIN	7	4.30	1.16
22. ATT WK	8	4.34	2.21
20. ATT SAFE	9	4.47	1.40
13. K/SK SAMP	10	4.64	1.53
2. K CH HS+1	11	4.96	2.04
17. SK ADAP	12	4.97	1.58
7. K ELEC PHYS	13	4.99	1.60
12. K FIR AID	14	5.08	1.37
24. ATT IMPROV	15	5.20	1.60
18. SK WRIT	16	5.36	1.49
4. K IN CH INT	17	5.38	1.67
5. K IN CH ADV	18	5.57	1.89
21. ATT EMPLOYR	19	5.91	1.84
6. K STAT	20	6.16	1.47
25. EXPER	21	6.31	1.62
11. K LAB MAN	22	6.57	1.27
9. K IN ORGPRO	23	6.65	1.47
8. K EMPLOYT	24	6.97	1.31
10. K WK STUD	25	7.07	1.39

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* - In all tables, except where otherwise indicated, the 7 responses from S.A.I.T. are not included. Hence in Table I, N = 74, not 81.

technicians and the laboratory supervisors, was added to moderate placements by the majority.

Order of Priority of Objectives, The Three Main Referent Groups. The three main referent groups are the Chemistry staff and the Principal of the Northern Alberta Institute of Technology, a sample of Representatives of Industry, and twenty-five of the Graduates of the 1965 and 1966 Chemical Technology courses at N.A.I.T.

In general it is clear from Table III, A, B, and C that all three groups attach most importance to the Chemical Technology's functions of extending knowledge of chemistry, developing skill in the laboratory, and concern with accuracy and precision, though there are differences, some statistically significant, as to which of these functions rates highest priority. The technicians appear to place relatively more emphasis on a high level of knowledge of chemistry (Item 3), and less on development of accuracy and precision (Item 2), the mean rank for the latter being significantly lower than the mean ranks allotted by both teachers and employers. The technicians and teachers agree on expecting a higher degree of sophistication in laboratory skill (Item 15) than the employers consider important, the difference again being significant.

On the other hand, employers as a group express more concern with attitude to work (Item 22) than teachers, and both rate this much more highly than the technicians. Teachers appear to attach more value to skill in interpreting instructions (Item 19) than employers or technicians, though these differences in means are not significant. There is a decided difference of opinion between the teachers and the other two groups with regard to skill in calibration, maintenance and minor repairs of equipment (Item 16). This skill may be more important in industry, particularly research oriented industry, than Institute courses acknowledge. The only other noteworthy difference towards the upper end of the priority scale concerns adaptability in the laboratory (Item 17). Teachers' opinions lie between those of employers and technicians who appear to have quite different views on this matter.

At the lowest priority end, all agree that work study (Item 10), laboratory management (Item 11), and knowledge of employment conditions and opportunities (Item 8), do not warrant much attention in the programme. Also, for the chemical technician, it seems that there is no need for pre-employment experience. (Item 25). Several respondents put this in the elimination category, and one

TABLE III

ORDERS OF PRIORITY OF OBJECTIVES, THE THREE MAIN REFERENT GROUPS

PART A

INSTITUTE STAFF

N = 11

Objective	Order of Priority	Mean Rank	Sig. Diff. Prob.* INDY	TECH
14. SK COM LAB	1	2.55		
23. ATT ACC	2	2.91	.004	.014
19. SK INTERP	3	3.45		
3. K CH HS+2	4.5	3.55		
15. SK SOPH LAB	4.5	3.55	.034	
1. K CH HS	6	3.91		
20. ATT SAFE	7.5	4.00		
22. ATT WK	7.5	4.00	.015	.039
13. K/S SAMP	9	4.55		
4. K IN CH INT	10.5	4.91		
17. SK ADAP	10.5	4.91	.053	
18. SK WRIT	12	5.00		
12. K FIR AID	13	5.09		
9. K IN ORGPRO	14.5	5.18	.00000	.00005
16. SK CAL MAIN	14.5	5.18	.017	.043
7. K ELEC PHYS	16	5.45		
5. K IN CH ADV	17	5.64		
2. K CH HS+1	18	5.82		
24. ATT IMPROV	19	5.91		
21. ATT EMPLOYR	20	6.09		
25. EXPER	21	6.27		
8. K EMPLOYT	22	6.37		
6. K STAT	23	6.64		
11. K LAB MAN	24	7.00		
10. K WK STUD	25	7.82		

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*- The entries: STAF (for Institute Staff), INDY (for Industry Representatives) and TECH (for Technicians) indicate the group with which there is a significant difference in mean rank for the particular objective.

TABLE III (CONTINUED)

PART B

INDUSTRY REPRESENTATIVES

N = 38

Objective	Order of Priority	Mean Rank	Sign. Diff. Prob.* STAF	TECH
23	1	2.58	.0004	.0009
3	2	2.71		
14	3	3.13		
1	4	3.68		
22	5	3.74	.015	.006
19	6	4.08		
15	7	4.21	.034	.016
16	8	4.26	.017	.006
2	9	4.55		
20	10	4.48		
13	11	4.61		
7	12	4.87		
24	13	4.95		
12	14	5.26		
17	15	5.37	.053	.028
4	16	5.45		
18	17	5.47		
21	18	5.55		
6	19	5.82		.054
5	20	5.89		
25	21	6.00		
11	22	6.50		
10	23	7.08		.044
8	24	7.11		
9	25	7.50	.00000	.00000

* - The entries: STAF (for Institute STAFF), INDY (for Industry Representatives) and TECH (for Technicians) indicate the group with which there is a significant difference in mean rank for the particular objectives.

TABLE III (CONTINUED)

PART C

TECHNICIANS

N = 25

Objective	Order of Priority	Mean Rank	Sign. Diff. Prob.* STAF	Sign. Diff. Prob.* INDY
3	1	2.48		
14	2	2.92		
15	3	3.20		.016
1	4	3.60		
23	5	3.72	.014	.0009
16	6	3.96	.043	.006
19	7	4.24		
17	8	4.40		.028
20	9	4.52		
13	10	4.72		
12	11	4.80		
7	12	4.96		
5	13	5.04		
2	14	5.20		
24	15	5.28		
18	16	5.36		
22	17	5.40	.039	.006
4	18	5.48		
9	19	6.00	.0005	.0000
21	20	6.36		
6	21.5	6.48		.054
11	21.5	6.48		
10	23	6.72		.044
25	24	6.80		
8	25	7.04		

* - The entries: STAF (for Institute Staff), INDY (for Industry Representatives) and TECH (for Technicians) indicate the group with which there is a significant difference in mean rank for the particular objective.

technician may have been expressing a fairly common opinion when he said experience "is not the business of the Institute". All groups give a low ranking to statistics (Item 6). (Note, however, that two or three respondents suggested in their comments, discussed later, that some introduction to computer principles is desirable.) The only significant difference noted at the lowest end of the scale was the employers' low rating of knowledge of industrial organization and process (Item 9), which was voted significantly higher by teachers and technicians.

Some speculative inferences from the above agreements and disagreements are discussed towards the end of this chapter.

Order of Priorities, Institute of Technology, Staff Sub-groups. Though the number of respondents involved was small it was considered useful to split the Institute Staff into two groups, one consisting of the Principal and two senior officers (Head of Chemistry Department and Senior Instructor) and the other of the eight instructors. No differences in means presented in the resulting Table IV were statistically significant, but a few notable differences in order of priority indicate that senior staff and teachers may have differences in expectations regarding outcomes of

TABLE IV

ORDER OF PRIORITY OF OBJECTIVES, INSTITUTE OF TECHNOLOGY SUB-GROUPS

SENIOR STAFF N = 3				INSTRUCTORS N = 8			
Objective	Order of Priority	Mean Rank	Sig. Diffs. Prob-abilities	Objective	Order of Priority	Mean Rank	Sig. Diffs. Prob-abilities
15. SK SOPH LAB	1	2.00		14.	1	2.25	
3. K CH HS+2	2	2.33		19.	2	2.88	
23. ATT ACC	3	2.67		23.	3	3.00	
14. SK COM LAB	4	3.33		1.	4	3.50	
13. K/SK SAMP	5	3.67		20.	5.5	3.88	
2. K CH HS+1	6	4.00		22.	5.5	3.88	
20. ATT SAFE	7.5	4.33		3.	7	4.00	
22. ATT WK	7.5	4.33		15.	8	4.13	
5. K IN CH ADV	9.5	4.67		4.	9.5	4.75	
12. K FIR AID	9.5	4.67		17.	9.5	4.75	
1. K CH HS	11.5	5.00		13.	11.5	4.88	
19. SK INTERP	11.5	5.00		18.	11.5	4.88	
4. K IN CH INT	15	5.33		9.	13.5	5.13	
9. K IN ORGPRO	15	5.33		16.	13.5	5.13	
16. SK CAL MAIN	15	5.33		7.	15.5	5.25	
17. SK ADAP	15	5.33		12.	15.5	5.25	
18. SK WRIT	15	5.33		5.	17.5	6.00	
24. ATT IMPROV	18	5.67		24.	17.5	6.00	
6. K STAT	20.5	6.00		8.	19.5	6.13	
7. K ELEC PHYS	20.5	6.00		21.	19.5	6.13	
21. ATT EMPLOYR	20.5	6.00		25.	21	6.38	
25. EXPER	20.5	6.00		2.	22	6.50	
8. K EMPLOYT	23	7.00		11.	23	6.75	
11. K LAB MAN	24	7.67		6.	24	6.88	
10. K WK STUD	25	8.00		10.	25	7.75	

* - No differences were statistically significant.

the programme.

In general senior staff members tend to display a greater concern with the intellectual development of the student than do the teaching staff, whose first concern appears to be operational competence. See, for example, the respective inverse placings of items 3 and 1, knowledge of chemistry, 5 and 4, levels of knowledge of industrial applications of chemistry, and 15 and 14, the two laboratory skill levels. A similar difference in intellectual/practical polarization seems to show in the difference in placement of items 19 and 17, concerned respectively with interpretation of instructions and adaptability in the laboratory, and of two or three other items, e.g. 7 and 8, whose higher ranking by teachers indicates a tendency towards emphasis on productive capacity. There is no doubt that work study (Item 10), laboratory management (Item 11) and pre-employment experience (Item 25) are considered of low priority.

The wide difference in the ranking of Item 2 is interesting. Senior officers seem to be saying that the ranking of knowledge of chemistry is directly proportionate to its intellectual level. (Items 3, 2 and 1 ranked in that order). Teachers on the other hand appear to believe

that technicians need a high level of specialized knowledge (Item 3) on a good base (Item 1 ranked high), and that a middle level of specialized knowledge is inadequate (Item 2 ranked very low).

In the absence of significant differences the above comments are put forward very tentatively.

In the composite ranking for all Institute staff in Table III, it is easy to trace the interplay of influence of one sub-group's ranking on the other. Naturally, because the number of teachers was greater than the number of senior staff, the overall Institute rankings follow the teachers' ranks closely, the most prominent departures being in Items 19 and 1 which were brought down by the senior staff's low rankings of these items, and conversely 3 and 15 which were raised in the scale.

Order of Priority of Objectives, Industry Representatives, Research/Production Sub-Groups. In interviews with technicians and employers in different laboratories it was quite commonly said that two different types of chemical technicians were needed to cater for the different needs of research, in which routine work was at a minimum, and productive industry, in which there was often a considerable amount of routine and repetitive analysis,

particularly in quality control work, which filled a large part of the technicians' time.

Table V seems to give a surprisingly clear picture of the differences in training requirements which arise out of the above distinction. With regard to nineteen of the twenty-five objectives, the research and production spokesmen are in very close agreement. A clear split, however, shows up on the other six objectives, four of the differences being statistically significant.

In research a higher level of instrumental sophistication (Item 15) is apparently expected of the technician, as well as greater concern with keeping up-to-date (Item 24) and perhaps more adaptability (Item 17), the differences in means for Items 15 and 24 being significant. The middle level of knowledge of chemistry (Item 2) appears to be fairly acceptable to producers but not to the researchers. Rank orders differ for this item but rank means are not significantly different. These findings are consistent with a statement from one university research department that it would in future prefer to recruit its assistants from B. Sc. ranks rather than from Institute graduates. They also indicate support for practice in Australian and British Technical Education which provide the higher level

TABLE V

ORDER OF PRIORITY OF OBJECTIVES, INDUSTRY REPRESENTATIVES, RESEARCH/PRODUCTION SUB-GROUPS

RESEARCH SUB-GROUP		N = 20		PRODUCTION SUB-GROUP		N = 18	
Objective	Order of Priority	Mean Rank	Sig. Diffs Prob.	Objective	Order of Priority	Mean Rank	Sig. Diffs. Prob.
23. ATT ACC	1	2.50		23.	1	2.67	
3. K CH HS+2	2	2.60		3.	2	2.83	
22. ATT WK	3	3.20		14.	3	2.89	
14. SK COM LAB	4	3.35		1.	4	3.61	
15. SK SOPH LAB	5	3.65	.022	2.	5	4.06	
1. K CH HS	6.5	3.75		22.	6	4.33	
19. SK INTERP	6.5	3.75		19.	7	4.44	
16. SK CAL MAIN	8	4.05		16.	8	4.50	
24. ATT IMPROV	9	4.30	.011	20.	9	4.56	
13. K/SK SAMP	10	4.45		4.	10	4.61	.001
7. E ELEC PHYS	11.5	4.60		13.	11	4.78	
20. ATT SAFE	11.5	4.60		15.	12	4.83	.022
2. K CH HS+1	13	5.00		7.	13	5.17	
17. SK ADAP	14	5.05		18.	14.5	5.28	
12. K FIR AID	15	5.20		25.	14.5	5.28	.001
21. ATT EMPLOYR	16	5.45		12.	16	5.33	
18. SK WRIT	17	5.65		5.	17	5.61	
6. K STAT	18	5.95		6.	19	5.67	
5. K IN CH ADV	19	6.15		21.	19	5.67	
4. K IN CH INT	20	6.20	.001	24.	19	5.67	.011
25. EXPER	21	6.65	.001	17.	21	5.72	
11. K LAB MAN	22	6.85		11.	22	6.11	
8. K EMPLOYT	23	7.00		10.	23	7.00	
10. K WK STUD	24	7.15		9.	24	7.17	
9. K IN ORGPRO	25	7.80		8.	25	7.22	

"technologist" programme as well as the middle level technician course. There may be an unacknowledged gap here in North American technical training provisions.

In a further contrast, statistically significant but probably not particularly important, the production employers are more interested in the technicians having some prior knowledge (Item 4) and experience (Item 25) of industry than the research men are, though neither group rates these items very highly.

Order of Priority of Objectives, Industry Representatives, Managers and Personnel Officers/Laboratory Supervisors. Industry representatives were again divided into two groups, this time according to their closeness to the laboratory situation in their firm. Those occupying managerial or personnel positions were placed in one group and those who acted as immediate supervisors of laboratories in the other group. It has been suggested that some of those who represent industry on Technical Education advisory committees may not be sufficiently in touch with current operational needs. Comparison of rankings of objectives by the two types of industrial representatives could possibly throw some light on this suggestion.

When research and production industries are considered

together (Table VI, Part A), and ranks for objectives are compared one by one between manager/personnel staff and laboratory supervisory staff, the most striking feature of the comparison is the degree of agreement in order of placement for the great majority of the items. The first three and the last six items are the same in both tables, with only slight changes in order, and most other items differ only by two or three places.

This makes the small number of differences stand out more sharply. The most significant statistically concerns Item 13, (sample preparation) and reflects the greater concern of the immediate supervisors of the laboratory with operational requirements. Except for attitude to accuracy and precision (Item 23), the managers and personnel officers tend to show more interest in the attitude group of objectives (Items 22 and 24), differences in rank order being quite marked but differences in means not significant. The supervisors show more concern than the more remote people with Items 12 (safety) and 19 (interpretation of instructions), and are less satisfied with one year of specialized instruction in chemistry (Item 2). None of these differences in means are significant but consistent differences in order of priority indicate supervisors' concern with immediate laboratory requirements.

When the groups are broken down further in Table VI, Parts B and C to distinguish the research-oriented from the production-oriented establishments some of the above differences in means are found to be significant. The evidence suggests that much of the manager/personnel emphasis on attitudes (Items 22 and 24) comes from the research group of managers and personnel officers, while much of the difference regarding Item 13 (sample preparation), Item 19 (interpreting instructions), Item 20 (safety), and Item 12 (First Aid) seems to spring from the production (mainly quality control) laboratory supervisors. As already noted from Table VI, the production people generally tend to rate attitudes 22 and 24 lower than the research group.

One other important difference that shows up when the sub-groups are broken down into research and production representatives is the ranking of Item 15 (sophisticated laboratory skills). Research laboratory supervisors appear to rank this item higher than their managers, while in the production area the reverse is the case. In the research field, the difference in mean ranks is significant. A similar comment applies to adaptability (Item 17), more prized by research supervisors and production managers, in

TABLE VI

ORDER OF PRIORITY OF OBJECTIVES INDUSTRY REPRESENTATIVES, MANAGERS AND PERSONNEL OFFICERS/LABORATORY SUPERVISORS

PART A

ALL INDUSTRY REPRESENTATIVES
N = 38

All Managers & Personnel Officers N = 15				All Laboratory Supervisors N = 23			
Objt.	O.P.	M.R.	Sig. Diff. Prob.	Objt.	O.P.	M.R.	Sig. Diff. Prob.
23	1	2.27		3	1	2.57	
3	2	2.93		23	2	2.78	
14	3	3.13		14	3	3.13	
22	4	3.20		1	4	3.65	
1	5	3.73		19	5	3.83	
2	6	4.07		15	6	4.00	
24	7	4.40		22	7	4.09	
15	8	4.53		13	8.5	4.13	.022
16	9.5	4.67		16	8.5	4.13	
19	9.5	4.67		20	10	4.39	
20	11	4.87		7	11	4.65	
17	12	5.13		2	12	4.87	
7	13.5	5.20		12	13	5.04	
18	13.5	5.20		17	14.5	5.52	
13	15	5.33	.022	21	14.5	5.52	
4	16	5.40		24	16	5.30	
6	18	5.60		4	17	5.48	
12	18	5.60		18	18	5.65	
21	18	5.60		6	19	5.97	
5	20	5.73		5	20	6.00	
25	21	5.80		25	21	6.13	
11	22	6.33		11	22	6.61	
10	23	6.73		8	23	6.78	.051
8	24	7.60	.051	10	24	7.30	
9	25	7.67		9	25	7.39	

TABLE VI (CONTINUED)

PART B

RESEARCH INDUSTRY

N = 20

Managers/Personnel N=8				Lab Supervisors N=12			
Objt.	Order	Mean Rank	Sig. Diff. Prob.	Objt.	Order	Mean Rank	Sig. Diff. Prob.
23	1	1.75	.040	3	1	2.25	
22	2	2.25	.014	23	2	3.00	.040
3	3.5	3.13		15	3	3.17	.046
14	3.5	3.13		14	4.5	3.50	
1	5.5	3.88		19	4.5	3.50	
24	5.5	3.88		1	6	3.67	
19	7	4.13		22	7	3.83	.014
16	8	4.25		16	8	3.92	
15	9	4.38	.046	13	9	4.08	
20	10	4.63		7	10	4.33	
2	12	5.00		20	11.5	4.58	
7	12	5.00		24	11.5	4.58	
13	12	5.00		17	13	4.83	
18	14	5.13		2	14	5.00	
12	15	5.25		12	15	5.17	
6	17	5.38		21	16	5.50	
17	17	5.38		18	17	6.00	
21	17	5.38		5	18	6.17	
4	19.5	6.13		4	19	6.25	
5	19.5	6.13		6	20	6.33	
25	21	6.63		8	21.5	6.67	
11	22	6.88		25	21.5	6.67	
10	23	7.00		11	23	6.83	
8	24	7.50		10	24	7.25	
9	25	7.88		9	25	7.75	

TABLE VI (CONCLUDED)

PART C

PRODUCTION INDUSTRY

N = 18

Managers/Personnel			N=7	Lab Supervisors			N=11
Objt.	O.P.	M.R.	S.D.P.	Objt.	O.P.	M.R.	S.D.P.
3	1	2.71		23	1	2.55	
23	2	2.86		14	2	2.73	
2	3	3.00	.034	3	3	2.91	
14	4	3.14		1	4	3.63	
1	5	3.57		13	6	4.18	
22	6	4.29		19	6	4.18	
4	7	4.57		20	6	4.18	
15	8.5	4.71		16	8.5	4.36	
16	8.5	4.71		22	8.5	4.36	
17	11	4.86	.045	4	10	4.64	
19	11	4.86		2	11	4.73	.034
25	11	4.86		12	12.5	4.91	
24	13	5.00		15	12.5	4.91	
20	14	5.14		7	14	5.00	
5	15.5	5.29		18	15	5.27	
18	15.5	5.29		6	17	5.55	
7	17	5.43		21	17	5.55	
11	18.5	5.71		25	17	5.55	
13	18.5	5.71		5	19	5.82	
6	20.5	5.86		24	20	6.09	
21	20.5	5.86		17	21	6.27	.045
12	22	6.00		11	22	6.36	
10	23	6.43		8	23	6.91	
9	24	7.43		9	24	7.00	
8	25	7.71		10	25	7.36	

the latter case with statistical significance.

In the production group, the laboratory supervisors are apparently less prepared than their managers to accept the lower degree of specialized knowledge denoted by Item 2, again the difference being significant. Production managers and personnel officers are unique among the four sub-groups in their relatively higher regard for experience (Item 25).

Order of Priority of Objectives, Technician Research/Production Sub-Groups. It was considered possible that one or two years of employment in the different atmospheres of research-oriented and production-oriented laboratories may have produced some differences in the retrospective outlooks of graduates of the Chemical Technology programme. Accordingly, the graduates were divided for comparison into two groups corresponding to the orientations of their firms.

In Table VII, only one pair of mean ranks (for attitude to accuracy and precision) showed significant difference and this did not have much effect on the placement of the item in the two scales of priorities. In fact there are no substantial differences between mean ranks

given to objectives by the two groups, though one or two tendencies shown in rank orders are in predictable directions. Research technicians evidently see less value in their basic studies of chemistry (Item 1) than the production workers, and are slightly less concerned with safety (Item 20) and First Aid (Item 12), are a little more concerned with adaptability (Item 17), self-improvement (Item 24), and loyalty to the firm (Item 21). The inverted placements by the two groups of Items 14 and 3 shows the same tendency. One might speculate, on admittedly very inadequate evidence, that chemical technicians who are attracted to research-oriented laboratories may be further along Vollmer's and Mill's professionalism ladder than those who seek more routine employment in production-oriented industry.[1]

Order of Priority of Objectives, N.A.I.T./S.A.I.T. Staff. Sample numbers were very small, hence comment on Table VIII particularly can only be very tentative. Only two differences in mean ranks were statistically significant, those of Items 3 and 9.

S.A.I.T. staff are more in line than N.A.I.T. with the overall ranking by all respondents of Item 3 (high level

TABLE VII

ORDER OF PRIORITY OF OBJECTIVES, TECHNICIAN SUB-GROUPS

RESEARCH TECHNICIANS		N = 12		PRODUCTION TECHNICIANS		N = 13	
Objective	Order of Priority	Mean Rank	Sig. Diffs. Prob.	Objective	Order of Priority	Mean Rank	Sig. Diffs. Prob.
3. K CH HS+2	1	2.25		14.	1	2.54	
15. SK SOPH LAB	2	2.67		3.	2	2.69	
14. SK COM LAB	3	3.33		1.	3	3.00	
23. ATT ACC	4	3.58	.046	15.	4	3.69	
16. SK CAL MAIN	5	3.83		23.	5	3.85	.046
19. SK INTERP	6	3.92		16.	6	4.08	
17. SK ADAP	7	4.17		20.	7	4.31	
1. K CH HS	8	4.25		19.	8	4.54	
13. K/SK SAMP	9	4.58		12.	9.5	4.62	
20. ATT SAFE	10.5	4.75		17.	9.5	4.62	
24. ATT IMPROV	10.5	4.75		13.	11	4.85	
7. K ELEC PHYS	12	4.92		5.	12.5	5.00	
12. K FIR AID	13	5.00		7.	12.5	5.00	
2. K CH HS+1	14.5	5.08		2.	14.5	5.31	
5. K IN CH ADV	14.5	5.08		22.	14.5	5.31	
18. SK WRIT	16	5.33		4.	16.5	5.38	
22. ATT WK	17	5.50		18.	16.5	5.38	
4. K IN CH INT	18	5.58		9.	18.5	5.77	
21. ATT EMPLOYR	19	6.17		24.	18.5	5.77	
9. K IN ORGPRO	20	6.25		6.	20	6.23	
11. K LAB MAN	21	6.58		11.	21	6.38	
6. K STAT	22	6.75		10.	23	6.54	
10. K WK STUD	23	6.92		21.	23	6.54	
8. K EMPLOYT	24	7.00		25.	23	6.54	
25. EXPER	25	7.08		8.	25	7.08	

TABLE VIII

ORDER OF PRIORITY OF OBJECTIVES, N.A.I.T./S.A.I.T. STAFF

NORTHERN ALBERTA INSTITUTE			N = 11	SOUTHERN ALBERTA INSTITUTE			N = 7
Objective	Order of Priority	Mean Rank	Sig. Diffs. Probs.	Objective	Order of Priority	Mean Rank	Sig. Diffs. Probs.
14. SK COM LAB	1	2.55		3.	1	1.57	.032
23. ATT ACC	2	2.91		14.	2	2.43	
19. SK INTERP	3	3.45		15.	3	2.86	
3. K CH HS+2	4.5	3.55	.032	23.	4	3.00	
15. SK SOPH LAB	4.5	3.55		1.	5	3.29	
1. K CH HS	6	3.91		13.	6.5	4.00	
20. ATT SAFE	7.5	4.00		19.	6.5	4.00	
22. ATT WK	7.5	4.00	.051	16.	8.5	4.14	
13. K/SK SAMP	9	4.55		18.	8.5	4.14	
4. K IN CH INT	10.5	4.91		20.	10	4.29	
17. SK ADAP	10.5	4.91		7.	11	4.71	
18. SK WRIT	12	5.00		12.	12	5.00	
12. K FIR AID	13	5.09		17.	13	5.14	
9. K IN ORGPRO	14.5	5.18	.006	2.	15	5.29	
16. SK CAL MAIN	14.5	5.18		4.	15	5.29	
7. K ELEC PHYS	16	5.45		24.	15	5.29	
5. K IN CH ADV	17	5.64		6.	17	5.71	
2. K CH HS+1	18	5.82		22.	18	5.86	.051
24. ATT IMPROV	19	5.91		25.	19	6.29	
21. ATT EMPLOYR	20	6.09		11.	20	6.43	
25. EXPER	21	6.27		5.	21	6.71	
8. K EMPLOYT	22	6.37		21.	22	7.00	
6. K STAT	23	6.64		9.	23	7.14	.006
11. K LAB MAN	24	7.00		8.	24	7.29	
10. K WK STUD	25	7.82		10.	25	8.00	

of chemistry knowledge) as of most importance. Reference back to Table IV will show that on this matter S.A.I.T. staff take the same view as N.A.I.T. senior staff members who tended to disagree with their teachers regarding the relative importance of Item 3.

Regarding Item 9 (knowledge of industrial organization and process), S.A.I.T. staff's low ranking is in close agreement with that of industry, who showed considerable difference of opinion from that of N.A.I.T. staff and of the technicians themselves. (See Table III).

The only other objectives which approached significance in differences were Items 22 (attitude to work) and 16 (skill in calibration, maintenance and repair). The rank orders indicate that the two Institutes may take opposite views with respect to the relative urgency of these two tasks of their programmes.

Apart from the above, the table does not provide any serious evidence of systematic differences in outlook between the staffs of the two Institutes.

Significant Correlations. The Reg 200 programme on the IBM 7040 printed out a table of correlations between objective items based on the original raw ranks assigned by the respondents. For seventy-four respondents (i.e. 72 degrees

of freedom) a correlation coefficient of 0.30 or higher is significant at the .01 level of confidence.[2] Table IX contains the correlation coefficients which exceeded this value.

The relatively high correlation between Items 12 and 20, safety and first aid, is not unexpected, as it is likely that respondents who tend to rate safety higher than other objectives will also tend to give a moderately high rank to first aid.

Some of the other correlations are less predictable and therefore of some interest.

The positive relationship of Items 1 and 2 when seen against the negative correlation of 1 with 3 seems to indicate a polarity along the dimension of depth of knowledge of chemistry, with some respondents tending to cluster at the high knowledge end (1 - 3 correlated negatively) and others at a more moderate level of expectation of knowledge of chemistry (1 - 2 positively correlated).

The most notable set of correlations is in the attitude items 21, 22, 23, 24 which seem to form a fairly solid group, indicating that respondents tended to have a generalized expectation towards attitudes, considering all the attitudes items together as relatively important or relatively unimportant. A disadvantage of the Q type of

TABLE IX

SIGNIFICANT CORRELATIONS BETWEEN OBJECTIVES AS RANKED BY 74 RESPONDENTS

Correlations of .30 and over are significant at the .01 level for 72 degrees of freedom. Correlations between the following pairs of objectives on the basis of raw rankings exceeded .30.

Objective Number	Correlation Coefficient	With Objective Number
1	0.32	2
	-0.34	3
2	0.32	1
3	-0.34	1
4	-0.30	22
	-0.40	24
5	-0.42	23
7	-0.31	22
10	-0.33	16
11	-0.32	24
12	0.50	20
14	-0.35	21
15	0.31	16
	-0.32	23
16	-0.33	10
	0.31	15
17	0.32	23
20	0.50	12
21	-0.35	14
	0.56	22
	0.36	23
	0.32	24
22	-0.30	4
	-0.31	7
	0.56	21
	0.50	23
	0.50	24
23	-0.42	5
	-0.32	15
	-0.32	17
	0.36	21
	0.50	22
24	-0.40	4
	-0.32	11
	0.32	21
	0.50	22

distribution is that it obscures any tendency that may be present towards a bimodal distribution. There is however some indication in Table VI that it is the managerial and personnel group in industry that is mainly responsible for the solidity of the attitude correlations.

The fairly definite negative relation of items 4 and 5, knowledge of industrial applications of chemistry, with the attitude items is rather puzzling. One is tempted to speculate that this may indicate a difference in viewpoint between a no-nonsense, no-frills group and an opposing broader outlook.

The negative relation of Item 23, (accuracy and precision) with Items 5 (advanced knowledge of industrial application), 15 (sophistication in laboratory skills) and 17 (adaptability) seems to be a fairly definite pointer to a possible routine versus adaptation polarization towards the duties of technicians on the job and confirms interpretations made from Tables V, VI and VII.

No logical patterns were discerned in the other pair of significant correlations.

II. COMMENTS BY RESPONDENTS

Of the eighty-one respondents, twenty-eight suggested

additional objectives for inclusion and thirty-four suggested eliminations.

The Eliminations. Most of those who suggested eliminations were content to remove their lowest ranked one or three items (Slots 8 and 9 in the Opinionaire, see Appendix A), some with comments which suggested that the reason for elimination was as much doubt as to the possibility of programming for attainment of these objectives as perceived lack of importance.

The items concerned and the frequency of elimination suggestions are listed below:

Item	Frequency
21	14
10	12
9	10
25	10
22	8
11	6
8	6
5	5
6	4
24	3
20	2

And the following once each: 1, 3, 4, 12, 13, 15, 17, 18, 19.

In view of the high to moderate rankings received from most respondents for many of the above items, some of the suggestions for elimination can hardly be taken too

seriously. With regard to such items as 21, 10, 9, and 25 which received consistent low ratings, the suggestions that these are not important or not the business of the Institute or not teachable do have to be given some consideration. It should however be recorded that several respondents, in the Opinionaire and in personal interview, expressed clear and positive opinions that all twenty-five objectives were important and relevant though in different degree.

One large firm appreciated the inclusion of their firm in the inquiry but returned all Opinionaires uncompleted, saying "It is our opinion that the purposes and curriculum to be covered by ... Technical Institutes ... can best be obtained by consultation between the Technical Institute and Advisory Boards."

The Additions. A wide range of additional objectives was proposed, few by more than one person. All of the additions were either knowledge or attitude items, and no new skills were identified, except for two references to ability to use library sources effectively.

The attitudes suggested were generally rather tenuous and in most cases even less capable of conscious development than those which were included in the Opinionaire. Typical

were "ability to work harmoniously with others", "proper attitude to authority", "self confidence", "scientific curiosity".

Of the knowledge items those which received two or three mentions each were:

biological aspects or relations of chemistry;

computer principles and language;

principles and practice of research techniques;

higher levels of mathematics, physics and/or electronics.

There were three or four suggestions for provision of more optional emphases in the programme, for example a chemical engineering bias or a food bias, though there was also a counter suggestion from several respondents that the programme should concentrate on general rather than special competencies. This latter view was expressed by one respondent as follows: "The main aim should be quality training in selected areas of knowledge, techniques and skills related to laboratory practice. This provides a larger technician pool and gives the technicians more flexibility in their choice of a job. On-the-job training will provide the specialization."

III. DISCUSSION OF FINDINGS

This discussion is restricted to consideration of the findings regarding the individual items which emerged directly from the tabulation and statistical treatment of the data, and with inferences which might follow if the data were assumed to represent reliable and adequate samples. Implications for judging the success of the Chemtech Opinionaire as an instrument are dealt with under conclusions in the final chapter.

The Individual Objectives

On the basis of the responses obtained, the following comments may be made regarding the individual objectives included as items in the Opinionaire:

Item 1. Knowledge beyond high school of theoretical principles and laboratory practices common to all branches of chemistry.

This was ranked consistently high by all groups and most sub-groups, and was ranked fourth overall. Its lowest rankings were 11th, from the senior staff at the Institute, and 8th from the research technician sub-group.

Item 2. Knowledge to a level one-year beyond high school of the main divisions of chemistry.

There were two distinct opinions with respect to this item, which finished close to the median position, with a relatively high standard deviation. The high rankers were the senior Institute staff, and the production side of industry, especially the managerial/personnel people in productive industry. The item was ranked very low by the Institute teachers, and generally a little below the median position by the remaining groups and sub-groups.

The split in opinion seems to represent one facet, concerned with level of specialized knowledge required, in the difference between research and quality control technicians.

Item 3. Knowledge to a level _two_ years beyond high school of one or more of the main divisions of chemistry.

This, along with Item 14, was clearly regarded as the most important objective. It was ranked a relatively low seventh by Institute teachers, but placed in the first three positions by all other groups and sub-groups.

Item 4. Knowledge at an introductory level of one or more of the main fields of industrial application of chemistry.

Another split vote was given to this objective, largely again along the lines of the research/production dichotomy. Overall this received a fairly low priority, seventeenth, but it was placed appreciably higher than this by the production group and sub-groups, as well as by the Institute staff, and somewhat lower than its overall position by research people.

Item 5. Knowledge at an advanced level of one or more of the main fields of industrial application of chemistry.

This was rated lower than Item 4 by all except the senior Institute staff, with a milder tendency to show the research/production division.

The unenthusiastic vote for Item 5, together with the moderate number of suggestions for its elimination (see page 95) seem to flow from two distinct views, namely that technicians engaged in research laboratories do not need to have much knowledge of industrially specialized chemistry, and that the production technicians need only be given an introduction to the industrial specializations.

Item 6. Knowledge beyond high school of statistical method.

Statistics were consistently rated low. The highest

ranking for this item was seventeenth, by the research manager/personnel sub-group and by the production laboratory supervisors. Otherwise it was generally in the lowest four or five ranks.

Item 7. Knowledge of the specific principles of electronics and physics involved in chemical instrumentation.

This was ranked at the median position by all except senior Institute staff and production manager/ personnel sub-groups, both of whom placed it seventeenth.

Item 8. Knowledge of opportunities and conditions of employment in the field of chemistry.

This was consistently placed in the lowest three ranks. Its highest rating was nineteenth, by Institute teachers, but only eight respondents suggested its elimination.

Apparently the general opinion is that students should be given this knowledge but that little time should be given to it in the formal programme.

Item 9. Knowledge of industrial organization and technological process.

This item produced very high levels of significance of difference between the three main referent groups and correspondingly marked differences in ranking. Institute

staff placed it near the median position, industry a unanimous last, and technicians midway between the other two. It received a relatively high number of elimination votes (page 95).

There seems to be an indication here that the teacher group are conscious that the student has educational needs (maybe conceptual or intellectual) which are distinct from his employment needs.

Item 10. Knowledge at an introductory level of work study and principles of supervision.

This item was rejected by almost every one and voted out by twelve respondents (second for elimination votes to Item 21).

Item 11. Knowledge of laboratory management procedures.

This was placed near last by all groups and subgroups.

Item 12. Knowledge of laboratory first aid.

First aid was placed in the median ranks by all subgroups except the production manager/personnel representatives, who placed it lower, and by the production technicians who valued it more than most respondents.

An interesting difference in viewpoints within the

production industries!

Item 13. Knowledge and skill in techniques of sample preparation.

This was generally ranked around the eighth to tenth position, except by the production manager/personnel people, who placed it well down the scale, and by their laboratory supervisors, who placed it well up the scale.

At this stage it is pertinent to digress a little to point to the number of times in this summary in which the production manager/personnel officers have been out of line with respondents as a whole as well as with the other industry representatives.

Item 14. Skill in using the common laboratory equipment, instruments and processes.

This was rated second overall, and never placed lower than fourth.

It is quite obviously a most important objective.

Item 15. Skill in using the more sophisticated or specialized laboratory instruments.

The more advanced level of skill was placed high by most, highest by the technicians, and lowest (ninth) by manager/personnel officers, from both the research and production side of industry. In this case the productive

laboratory supervisors supported their managers' low ranking, while the research supervisors seemed to disagree with their manager/personnel officers' opinion.

Item 16. Skill in calibration, maintenance and minor repair of laboratory equipment and instruments.

This is another case in which the three main referent groups differed significantly. Technicians ranked this in the top quartile, Institute staff below the median, and industry in between. Opinion within each group was surprisingly unanimous.

It may be in this case that it is the Institute which is out of line with an industrial need.

Item 17. Skill in adapting laboratory equipment or processes for special research or industrial needs.

Though placed by most groups within the middle third positions, there was a fairly clear division of opinion. Institute teachers, production manager/personnel officers, and the technicians placed this item towards the top of the middle third, while senior Institute staff, and industry representatives, especially production laboratory supervisors, placed it towards or below the bottom of the middle third of the rankings.

Item 18. Skill in writing technical reports.

This was placed fairly consistently around the fifteenth to eighteenth positions.

Item 19. Skill in interpreting technical instructions.

Interpretation of instructions was ranked consistently in the top quartile, except by the manager/personnel officers in production industry, who ranked it eleventh.

Item 20. Positive attitude to safety.

Safety was considered slightly less important by industry than by teachers and technicians, with the production manager/personnel people at some variance with their laboratory supervisors who gave safety a higher rating than all other sub-groups did.

Item 21. Positive attitude to the employing firm.

This was placed generally in the lowest quartile, except by the laboratory supervisors in both research and production industry.

This may have some relation with theoretical propositions concerning middle-level supervision.

Comments in interviews and a large number of elimination votes (page 95) suggest that respondents do not feel the Institute programme can effectively deal with this objective.

Item 22. Positive attitude to work.

The overall rank was eighth, but the high standard deviation reflects the divergence in opinion shown by the three main groups. Most significant statistically and largest in rank discrepancies was the difference between the employers, who rated this consistently high, and the technicians who placed it low in the scale. Institute staff ranked it between the other two.

Item 23. Positive attitude to accuracy and precision.

Respondents agreed unanimously that this was among the most important objectives, one or two sub-groups placing it first.

Item 24. Positive attitude to self-improvement.

Self-improvement was rated within the middle third of items, surprisingly lower by the educators than by the employers generally and the technicians.

There is a significant difference between the research and production sub-groups in industry, the research people rating this much higher. There is also a tendency for the industry manager/personnel officers to attach more importance to this attitude than their laboratory supervisors do. The latter difference may be related to naturally different concerns regarding mobility of employees.

Item 25. Experience in industry.

Whatever views there may be regarding the experience needs of professional and skilled workers, it seems clear from the responses obtained in this study that technicians do not need pre-employment experience to fit them for their job. The only sub-group which did not place Item 25 near the lowest rank was the production industry manager/personnel sub-group. All others evidently felt that as long as the Institute develops the necessary knowledge, skills and attitudes, technicians can be readily assimilated into the specialized operations of industry.

Conclusion to Chapter III.

In this chapter an analysis has been made of the opinions of respondents expressed in the form of tables of priorities they assigned to the twenty-five objectives presented to them. From this analysis tentative inferences were drawn about each of the twenty-five objectives in turn.

The next chapter begins with a summary of these factual and inferential outcomes of the analysis of data, and the thesis concludes with an appraisal of the Chemtech Opinionaire based on these outcomes.

REFERENCES TO CHAPTER III

(1) Howard M. Vollmer and Donald L. Mills, *Professionalization* (Englewood Cliffs, N.J.: Prentice-Hall, 1966), p. 2.

(2) G. A. Ferguson, *Statistical Analysis in Psychology and Education* (New York: McGraw-Hill, 1966), p. 413. (Interpolated.)

CHAPTER IV

RECAPITULATION, SUMMARY AND DISCUSSION

The general purpose of this study, as stated at the beginning of the first chapter, was to contribute towards clarifying purpose in Technical Education by an examination of the concept of occupational competence as the goal of training programmes.

An instrument was developed which presented occupational competence for chemical technicians as a composite of twenty-five elements organized under four distinct types, and proposed those components as the objectives of the technicians' training programme.

Another line of analysis began with an examination of the forces which influence purpose in Technical Education and suggested that the objectives for the Chemical Technology course might not be absolutes but rather might be to an extent dependent on the value-directed perceptions of different interested groups.

The specific purpose of the pilot study was to test if the instrument which had been developed, the Chemtech Opinionaire, presented a statement of objectives for the technicians' training programme which explicitly and adequately

represented the views of those with a legitimate interest in the course. One pointer to the effectiveness of the Opinionaire for this purpose would be its capacity to reflect differences as well as agreements in the opinions of the different groups consulted.

The Opinionaire was administered to three interested groups and the opinions of the groups were analysed. The results of this analysis are summarized below.

The summary is followed by a discussion of the potential contribution of the opinionaire technique towards clarification of goals in Technical Education, and the chapter concludes with a brief appraisal of the Chemtech Opinionaire.

I. SUMMARY OF THE MAIN INDICATIONS FROM THE ANALYSIS OF DATA

Once again, it becomes necessary to stress the limitations inherent in the pilot nature of this study, and at this stage particularly the restricted sizes of the samples of the referent groups. The word "indications" is therefore used here rather than "findings" in describing the factual and inferential outcomes of the above analysis of data.

Bearing this in mind, the following are indicated:

(i) The three most important tasks for the chemical technology programme are: (a) to help the aspiring technician to acquire a high level of specialized knowledge of chemistry on an adequate general base, (b) to develop skill in operating the common laboratory equipment and processes, and (c) to ensure an attitude of accuracy and precision towards laboratory work.

(ii) On the other hand a number of other tasks, though considered by most respondents to warrant some attention, are clearly assigned low priority as objectives. The "intangible outcomes" of experience abstracted by this writer from consideration of apprenticeship and internship prescriptions are obviously of little concern to most respondents to the inquiry. Knowledge of the housekeeping and procedural management of laboratories also appears to be of little, if any, importance, as is knowledge of the principles of work study and supervision. Regarding employment opportunities and conditions, it seems to be assumed that these are sufficiently well known or that they can be discovered without much difficulty.

(iii) Evidence from the Opinionaire provides objective support, such as it is, for the subjective

suggestion that some types of advisory committee members may not have views which are truly representative of their industry's operational requirements. One of the firmer patterns which emerged in the analysis of data was the frequency with which the manager/personnel sub-group was at variance with the majority or with their own supervisors and technicians. The evidence for this, even if it were more reliable than it can be in this limited study, is not of course a basis of judgement as to whether the managers or their supervisors and technicians are more correct in their assessment of industry's needs. What it does imply, however, is that the broader or higher needs of the firm at large (e.g. for horizontal or vertical mobility of staff) should be recognized as such and not confused with the operational needs of the laboratory.

(iv) The Opinionaire also provides objective indicators of the existence of two different types of technician functions, one in research or teaching establishments and one in producing or quality control areas. It also points to two or three characteristics of the preparation programme which might be changed to suit these different functions, in particular differentiation of levels of specialized knowledge of chemistry and of sophistication

in instrumental equipment.

(v) There is some suggestion in the evidence that the teaching staff members, particularly the senior ones, are conscious of other needs of the student as well as the need to prepare for the job. The teachers' motivating values may be commitment to intellectual development as such, or it may be desire to give the student better perspective to help his psychological adjustment to his job.

(vi) Some concern seems to emerge with the question as to if and how certain objectives, especially attitudes, can be achieved in the programme.

(vii) The analysis of data distinguished a number of objectives, including some at middle priority levels, about which opinion was quite unanimous, from several others about which opinion was rather sharply divided.

(viii) The responses to the Opinionaire indicated, though only at a fairly incipient stage, one or two of the issues involved in the concept of partnership in training responsibilities between Industry and the Technical Institute.

II. DISCUSSION

The above summary demonstrates that despite its limitations as used in this pilot study the opinionaire technique is capable of providing useful insights into purposes which a technical institute programme is expected to meet. The evidence presented is considered sufficient to justify replication of the pilot study on a more extensive scale to improve the potential of the evidence and to warrant trials of the same kind of technique in other areas and aspects of Technical Education.

Areas in which Q-sort opinionaires may prove to be useful analytical tools are illustrated by the following:

(a) Preparation of competence profiles which would show the relative proportions of knowledge, attitude, skills, and experience required for particular occupations or for different hierarchical levels of occupations. This sort of information has many implications for training programmes.

(b) Examination of the concept of shared responsibility for training between Industry and Technical Education. Development and implementation of this potentially profitable concept are limited by a serious communication problem

between these two spheres. The opinionaire technique is an inexpensive and effective instrument which could be readily adapted to facilitate systematic exchange of information between the two.

(c) A search for common core curriculum possibilities in the occupational spectrum. This could effect significant economies in class sizes, staffing and duplication of services within Institutes of Technology, as well as help to improve working relationships on the job between different occupational groups working with the same clientele or facilities, for example nurses, physiotherapists and medical laboratory technologists.

(d) An urgent need of planners and decision makers in Technical Education is a comprehensive understanding of the complex nature of goals in this field which would enable them to take satisfactory account of the many forces which influence the goals.

This pilot study was judged to have had some success in its examination of three of the sources of forces affecting one programme, but a single limited study of this kind is not an adequate basis for the type of conceptual framework needed. It is believed, however, that such a framework could be developed by a coordinated series of such studies, in which

the opinionaire would be used as one analytical tool, and for which the basic concept might be a general theory of goals such as that of H. A. Simon mentioned in Chapter II of this thesis on page 33.

III. APPRAISAL OF THE OPINIONAIRE TECHNIQUE AS A METHOD OF ESTABLISHING GOALS

It is claimed that the following conclusions regarding the effectiveness of the Chemtech Opinionaire have been demonstrated:

(i) That the Opinionaire is a suitable vehicle for obtaining expressions in explicit terms of the objectives of the Chemical Technology programme at an Institute of Technology.

(ii) That the Opinionaire has capacity to identify agreements and disagreements in perceptions of different referent groups with regard to these objectives.

These specific conclusions favour tentative adoption of two more general judgements concerning the potential usefulness of opinionaire techniques in establishing goals for Technical Education. First, a trial is considered to be warranted of the same kind of technique in other technological fields and at other levels in Technical Education.

Second, goals in Technical Education originate in several different classes of determinants, including the general

and specific characteristics of jobs, the needs and capacities of the learners, and the complicated and changing demands of society. Some of these determinants are capable of more or less precise measurement and exact description, and progress is being made in the study of these factors and in the utilization of the knowledge thus gained to improve policy-making processes in Technical Education. It will, however, be many years before all determinants will be analysed and known adequately. Subjective judgement, preference and intuition, founded in varied experiences and values, will continue to play a significant part in the formulation of goals in Technical Education. To the extent that this statement is true, opinionaire techniques, it is believed, will help to replace subjective estimates of this body of subjective opinion with objective measurement of it. This alone will be an improvement. Systematic opinionaire techniques might also contribute much more, by being used in conjunction with the increasing research effort into other facets of goal determination to raise the level of conceptual understanding of purpose in Technical Education.

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APPENDIX A

CHEMTECH OPINIONAIRE

This Opinionaire is being used to record opinions about the purposes of Chemistry Technology programmes in Institutes of Technology. Opinions are being sought from representatives of the chemical industries, from those who have completed chemical technology courses, and from those who teach these courses.

Your cooperation in following the instructions overleaf will be appreciated.

You will note that your name is not required. In those cases where the identity is apparent anonymity will be absolutely protected.

PLEASE RETURN THIS BOOKLET AS SOON AS CONVENIENT TO

Mr. J.G. Williams,
c/o Department of Educational Administration,
University of Alberta,
Edmonton, Alberta, Canada.

Please answer the following questions:

For industry representatives and graduates of Chemical Technology courses

What is the name of your firm?--

How many people are employed in the plant where you work?---------------------------
approx.

How many professional chemists are employed at your plant?--------------------------

What are the main products (or services)?---

What are the main raw materials used?---

What is the title of your particular position?--------------------------------------

What are your main tasks in this position?--

For Institute of Technology staff

What is the name of your Institute?---

What is the title of your position?---

What subjects are you teaching this year?---

Chemical technicians acquire their knowledge, skills, attitudes, and that "know-how" which comes with experience, from a mixture of organized and incidental influences, including school, industry, Technical Institute, friends, T.V., films, etc. Some things a chemical technician needs are best learned in a formal course of training at the Institute of Technology, others may be more appropriately learned elsewhere, perhaps in earlier schooling or maybe later on the job.

In this inquiry you are being asked to express your opinion as to what are the most appropriate things for the technician to learn at the Institute of Technology.

Objectives which have been proposed for Chemical Technology programmes are shown on the twenty-five cards attached to this page, and you are asked to sort them into nine groups or piles as follows: -

1 the om bel rt th hree ary p the e t
r wh ons most t for e co the ce t or
impo avi emain e cen

2 rt t -fi into es, t u co ost in in th pile
ext i in nd pi HREE rtan third OUR xt,
ext, in n pil in th pi n the and imp
the e.

3 that so card s of e a iate s fo titu
logy t, erms ance othe .

4 the es o in th ots b tu next

KNOWLEDGE BEYOND HIGH SCHOOL
(1) OF THEORETICAL PRINCIPLES AND LA
COMMON TO ALL BRANCHES OF CHEMIS

KNOWLEDGE TO A LEVEL ONE YEAR BEYOND HIGH S
(2) OF THE MAIN DIVISIONS OF CHEMISTR
eg. quantitative, qualitative, an
organic, inorganic, physical, sto

KNOWLEDGE AT AN INTRODUCTORY LEVEL
OF ONE OR MORE OF THE MAIN FIELDS
(4) APPLICATIO
eg. oil, plastics, food, etc. che

KNOWLEDGE OF THE SPECIFIC PRINCIPLES OF ELE
PHYSICS INVOLVED IN CHEMICAL INST
(7)

KNOWLEDGE OF LABORATORY MANAGEMENT PROCEDURE
(11) eg. stores control, routing and re
sam

SKILL IN CALIBRATION, MAINTENANCE, AND MIN
(16) OF LABORATORY EQUIPMENT AND INSTRUME

POSITIVE ATTITUDE TO SAFETY
(20) eg. care with hazardous materials,
use of protective devices, etc.

POSITIVE ATTITUDE TO ACCURACY AND PRECISION
(23) eg. care in measuring and recording

EXPERIENCE IN INDUSTRY
(25) eg. planned periods of employment d
or in vacation.

One card	Two cards	Three cards	Four cards	Five cards	Four cards	Three cards	Two cards	One card
the most important	next most important	next most important	next most important	next most important	next most important	next most important	next most important	next most important

You may believe that there are other objectives which Chemical Technology programmes should attempt to achieve. If so, please state them and indicate which of the above piles or slots you would place them in.

------------------------------( ) ------------------------( )

------------------------------( ) ------------------------( )

You may believe that some of the objectives to which you gave a low rating on the previous page are not the business of the Institute of Technology at all. If so, please indicate which pile/s of items you feel should be eliminated.

Pile number 9-------- 8----------- 7---------- 6----------
(check as appropriate)

THANK YOU FOR YOUR COOPERATION. An early return would be appreciated.

APPENDIX B

TABLE X

RAW RANKS OF OBJECTIVES BY ALL RESPONDENTS

Respondent	I T E M									N U M B E R															
Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
N.A.I.T.																									
1	8	5	1	7	3	6	6	8	4	7	9	7	4	5	3	6	5	5	5	6	2	3	2	4	4
2	2	2	5	4	4	8	5	7	5	9	6	4	3	3	1	6	5	6	6	4	7	5	3	7	8
3	5	5	1	5	7	4	7	6	7	8	8	3	4	2	2	4	6	5	4	3	9	5	3	6	6
4	4	4	7	7	7	6	4	5	5	8	8	3	6	2	3	3	9	6	4	5	5	2	1	5	6
5	4	8	3	4	8	9	5	5	4	7	8	6	6	1	4	6	6	7	2	2	7	3	3	5	5
6	5	8	2	6	3	9	3	6	4	6	5	6	7	1	2	5	5	4	3	4	7	8	5	7	4
7	5	6	6	1	6	5	7	6	4	5	8	3	5	4	7	5	3	2	2	3	7	4	4	8	9
8	3	6	5	5	5	7	4	5	6	9	7	5	2	1	6	6	2	8	3	4	7	4	3	4	8
9	1	5	4	7	5	8	7	8	6	9	5	6	5	3	5	7	3	4	2	4	4	2	3	6	6
10	5	7	3	6	6	5	6	8	7	9	8	8	4	3	3	5	5	4	2	4	5	1	2	6	7
11	1	8	2	2	8	6	6	6	5	9	5	5	4	3	3	4	5	4	5	5	7	7	3	7	6
S.A.I.T.																									
1	4	4	1	4	6	6	4	9	8	8	6	5	5	3	2	3	6	2	5	3	7	5	5	7	7
2	2	7	1	7	8	5	5	5	8	9	7	5	4	2	3	4	5	4	3	4	6	6	3	6	6
3	1	2	2	6	6	4	4	7	8	8	6	5	4	3	3	5	5	5	4	5	9	7	3	7	6
4	6	5	1	6	7	4	3	9	8	8	5	4	4	2	3	5	3	4	5	5	7	6	2	6	7
5	2	6	4	4	7	8	8	4	5	6	6	6	5	3	5	3	7	5	3	4	9	7	2	1	5
6	5	7	1	6	7	6	5	9	8	8	7	5	3	2	2	5	6	4	3	5	4	4	3	4	6
7	3	6	1	4	6	7	4	8	5	9	8	5	3	2	2	4	4	5	5	5	7	6	3	6	7

Respondent Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Industry Research																									
1	5	6	1	6	6	6	4	9	8	5	8	7	5	3	5	4	4	5	3	7	4	3	2	2	7
2	4	5	3	7	5	8	6	7	8	8	6	5	4	2	1	4	5	6	2	5	6	3	4	3	7
3	4	9	1	5	7	7	5	7	8	6	6	6	3	2	4	5	5	6	3	5	4	3	2	4	8
4	1	7	2	6	8	6	4	6	7	9	8	5	5	5	3	4	4	6	4	3	5	2	3	5	7
5	4	4	1	9	5	5	2	7	7	8	8	6	5	5	2	3	4	5	6	6	6	3	3	4	7
6	2	4	5	5	6	6	8	8	7	7	5	5	3	3	4	3	4	6	6	5	4	2	1	7	9
7	3	2	5	6	6	6	4	6	9	8	8	4	3	5	4	5	7	7	3	4	7	2	1	5	5
8	2	4	1	4	2	5	3	9	8	6	8	7	4	3	3	4	5	7	5	5	6	6	5	6	7
9	4	6	1	6	4	5	5	7	9	6	4	4	2	2	3	3	3	5	5	7	8	7	6	8	5
10	3	5	9	8	8	5	5	7	6	6	5	5	3	3	6	4	6	4	4	4	7	1	2	2	7
11	4	3	2	7	7	6	4	6	9	7	8	5	4	6	5	5	5	8	4	5	3	2	1	3	6
12	3	4	2	8	7	5	5	8	9	6	7	4	5	4	3	2	6	6	6	4	5	3	1	5	7
13	5	8	1	3	5	6	6	7	9	7	8	5	7	2	4	4	4	5	4	5	6	3	2	3	6
14	6	5	1	6	8	7	3	5	9	8	6	5	6	5	3	4	3	7	2	4	5	4	2	4	7
15	3	1	8	6	7	6	3	7	7	6	5	6	5	2	2	4	5	5	4	4	9	4	3	5	8
16	2	5	5	5	5	9	6	8	7	8	7	4	3	3	6	3	6	6	2	4	4	4	1	5	7
17	8	5	1	8	7	5	6	5	7	7	8	4	3	2	4	4	6	6	2	3	6	5	3	4	5
18	3	5	1	5	6	4	4	9	8	8	7	6	6	2	5	7	7	4	4	5	5	2	3	3	6
19	2	6	1	6	9	7	5	6	7	8	8	5	5	5	2	4	7	5	3	4	4	3	3	4	6
20	7	6	1	8	5	5	4	6	7	9	7	6	8	3	4	5	5	4	3	3	5	2	2	4	6

Industry Production

Respondent Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	1	3	2	3	3	6	6	7	8	5	5	9	6	2	4	5	7	7	6	8	5	4	4	4	5
2	4	7	7	5	7	5	8	6	9	5	6	4	2	3	6	5	8	5	3	3	4	1	2	6	4
3	1	2	2	6	7	4	7	7	8	9	5	6	4	3	8	5	6	6	3	5	4	4	3	5	5
4	5	6	3	6	7	6	8	9	5	7	7	5	4	4	5	5	3	8	6	3	2	1	4	2	4
5	2	4	5	6	7	6	7	6	8	9	8	4	3	4	5	5	7	6	3	2	4	3	1	5	5
6	2	4	5	3	4	5	5	6	7	8	7	3	4	1	3	2	7	5	6	4	9	8	5	6	6
7	6	4	3	5	4	7	5	9	7	8	6	6	7	3	5	4	5	4	8	2	2	1	3	5	6
8	3	5	3	5	6	9	6	8	7	6	7	6	4	4	4	5	8	5	5	3	2	1	2	7	4
9	5	2	1	3	4	6	7	5	8	7	7	6	8	2	5	6	4	3	4	5	9	4	3	5	6
10	3	1	4	5	6	5	4	9	8	6	5	4	5	2	3	3	4	6	5	7	8	7	2	7	6
11	5	6	1	3	8	5	3	7	7	9	6	3	6	2	8	5	7	6	5	4	4	4	2	4	5
12	2	2	1	4	7	6	5	7	8	7	6	5	5	3	4	6	5	4	3	4	6	9	3	8	5
13	4	4	5	5	5	4	3	9	7	6	5	6	2	1	2	3	7	6	5	4	8	7	3	8	6
14	6	6	1	7	9	5	4	6	7	8	8	5	3	2	5	3	4	4	3	4	6	5	2	5	7
15	3	6	1	4	6	6	2	5	5	7	9	5	5	2	4	4	5	6	3	4	8	8	3	7	7
16	6	3	1	4	3	4	4	8	6	5	4	8	6	5	3	5	5	7	6	9	7	2	2	7	5
17	3	3	5	6	6	5	3	8	8	5	4	7	5	6	7	4	6	5	2	7	9	4	1	4	2
18	4	5	1	3	2	8	6	8	6	9	5	4	7	3	6	6	5	2	4	4	5	5	3	7	7

Respondent Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Technicians																									
1	1	4	2	5	9	5	8	6	7	6	6	3	5	4	2	5	7	8	6	3	4	4	3	5	7
2	6	4	1	5	5	9	5	7	7	5	6	7	4	2	4	3	8	6	3	5	6	2	3	4	8
3	1	2	5	5	7	7	8	8	5	6	6	3	4	2	3	3	5	5	4	4	9	7	4	6	6
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5	1	5	4	5	3	6	6	8	8	7	7	6	7	5	2	4	4	6	4	5	3	3	5	2	9
6	7	8	1	7	7	5	3	8	6	6	5	5	2	3	4	2	4	4	4	5	6	6	3	5	9
7	3	7	5	5	6	7	4	9	6	6	8	5	7	2	2	4	1	6	4	5	8	5	4	3	3
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15	1	5	2	6	5	4	6	5	2	7	9	6	3	4	5	6	4	3	3	7	8	7	5	4	8
16	1	3	4	3	5	5	5	6	6	5	6	6	3	2	4	2	4	5	4	7	9	7	7	8	8
17	1	7	5	7	5	9	4	6	8	8	7	3	4	2	5	4	5	5	6	3	4	2	3	6	6
18	7	8	1	7	4	9	4	8	5	6	6	5	3	2	4	5	5	6	3	5	7	3	2	4	6
19	5	3	2	3	3	9	5	6	6	8	6	5	4	1	2	4	4	7	4	5	7	6	5	7	8
20	2	3	3	4	9	6	7	7	6	6	6	4	8	1	5	5	7	8	5	4	5	4	2	5	3
21	1	2	3	3	6	8	5	6	5	5	6	5	5	2	3	4	4	8	7	4	7	7	4	6	9
22	1	2	2	3	8	7	4	7	6	9	6	5	5	3	4	5	4	5	4	5	8	6	3	6	7
23	1	8	2	8	6	4	5	7	7	9	5	2	4	3	5	5	5	4	4	3	6	6	3	7	6
24	6	6	3	4	6	6	5	9	8	5	5	4	8	1	2	2	4	4	3	3	7	7	5	5	7
25	5	7	1	9	4	5	5	8	5	6	8	7	5	2	2	4	6	7	6	4	6	4	3	3	3

APPENDIX C

EXAMPLE OF COMPUTER PROGRAMME

The following programme was used to obtain the mean ranks for each objective for all respondents combined, and for testing the significance of differences of group mean ranks between successive pairs of the three referent groups. The print-out also provided correlations between rankings of objectives.

(1) An IBM card was punched for each respondent as follows:

Column		Variable
21-25	Ranks assigned by respondent to the 25 objectives.	$X_1 - X_{25}$
51	Main Group Identification 1 = N.A.I.T. 2 = S.A.I.T. 4 = INDUSTRY RESEARCH 5 = INDUSTRY PRODUCTION	X_{26}
52	Sub-Group Identification 1 = Principal 2 = Head of Department or Senior Instructor 3 = Instructor 4 = Manager/Personnel 5 = Laboratory Supervisor 7 = Technician	X_{27}

(2) Categorical vectors X_{28}, X_{29}, X_{30} were generated from variables X_{26} and X_{27} to represent, respectively, Institute Staff, Industry Representatives, and Technicians.

(3) The following Models were set up, to predict the mean rank of each objective in turn from group membership:

(a) to compare Mean Ranks of Institute Staff and Industry Representatives.

Full Model

Model 01 $X_1 = w_1 X_{28} + w_2 X_{29} + e$

Model 02 $X_2 = w_1 X_{28} + w_2 X_{29} + e$

Model 03 $X_3 = w_1 X_{28} + w_2 X_{29} + e$

.. ..
.. ..

Model 25 $X_{25} = w_1 X_{28} + w_2 X_{29} + e$

Restricted Model

Model 99 $X_i = w X_{99} + e$

where $X_{99} = X_{28} + X_{28}$

(b) to compare Mean Ranks of Institute Staff and Technicians.

Full Model

Model 01 $X_1 = w_1 X_{28} + w_2 X_{30} + e$

Model 02 $X_2 = w_1 X_{28} + w_2 X_{30} + e$

.. ..
.. ..

Model 25 $X_{25} = w_1 X_{28} + w_2 X_{30} + e$

Restricted Model

$X_i = w X_{99} + e$

where $X_{99} = X_{28} + X_{30}$

(c) to compare Mean Ranks of Industry Representatives and Technicians.

Full Model

Model 01 $X_1 = w_1 X_{29} + w_2 X_{30} + e$

Model 02 $X_1 = w_1 X_{29} + w_2 X_{30} + e$

.. ..
.. ..

Model 25 $X_{25} = w_1 X_{29} + w_2 X_{30} + e$

Restricted Model

Model 99 $X_i = w X_{99} + e$

where $X_{99} = X_{29} + X_{30}$

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